COMPRESSED AIR

AND EVERYTHING PNEUMATIC.

Vol. XIII JULY, 1908 No. 7

RECENT DEVELOPMENTS IN PNEUMATIC FOUNDATIONS FOR BUILDINGS*

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The purpose of this paper is to review briefly the recent and very interesting development in foundations of the class generally used for the high buildings being erected in the lower section of New York City. The earth there overlies a stratum of rock, the depth of which varies from 40 to 100 ft., and the enormous loads are carried most securely by concrete piers built with pneumatic caissons, and resting directly on the substratum of rock.

Prior State of the Art.—Prior to the present improvements, the conventional type of construction was as illustrated in Figs. 1 and 2. The working chamber was built with sides and roof of heavy timber or of sheet steel with stiffeners at suitable intervals. The coffer-dam was built up in successive sections (also of timber or stiffened steel), the horizontal joints being made by angles on the inside, and the walls being braced by transverse struts, where the shape and size demanded it. The shaft was of steel tubing fastened to the roof and at the several horizontal joints by outside angles.

As the structure was sunk, to bring the upper edge of each section of the coffer-dam near the ground level, a new section of coffer-dam and a new section of shafting were added, and the space between the coffer-dam and the shafting was filled with concrete. When bed-rock was reached, the working chamber and the shaft were also filled with concrete. The finished pier consisted of two entirely separate bodies of concrete—an inverted T-shaped portion bounded by the shafting and the roof and walls of the working chamber, and a ring-shaped portion surrounding the shaft and enclosed within the coffer-dam.

The surrounding shell, consisting of the coffer-dam and the sides of the working chamber, whether of timber or of steel, could only be considered a mould for the concrete and a curb or lining for holding back the earth during the sinking of the caisson. It could not be calculated as supporting any weight, but, on the contrary, was certain to rot or corrode in time, and leave a more or less free space around the pier. The shafting, and especially the roof, where the latter was of metal and was left in place, presented very serious possibilities. Their protection from corrosion depended on the care with which the concrete was rammed into contact with them. If either corroded to a substantial extent, it would produce a very large surface of weakness. The permanence of these important elements of the structure, therefore, depended on the care of workmen, who are not to be relied on for more care than is necessary at the moment. Furthermore, the angles at the several horizontal joints formed grooves in the concrete from 3 to 6 in. deep. Only under unusually favorable conditions could the shafting angles be calculated to act as supporting a share of the load in the ratio of their horizontal area to that of the complete cross-section of the pier; but the angles at the joints of the coffer-dam would not transmit any substantial pressure to the concrete below them, because the concrete would never be rammed under them sufficiently. The only transmission of pressure would be to the decaying or corroding walls, and the angles themselves would corrode in time. The greatest area upon which the bearing strain could be calculated correctly, therefore, was that within the inner edge of the angle-irons (X, Fig. 2), rather than that within the inner face of the coffer-dam (Y, Fig. 2). As a matter of fact, the latter standard was generally

*Presented at the New York meeting, April 1908, of the American Society of Civil Engineers.

used, but the error was swallowed in the large factor of safety made necessary by the uncertainties of the problem. Furthermore, the useless, and to some extent harmful, materials left in the ground, were very expensive parts of the structure.

There were thus two powerful incentives for the elimination of these materials from the finished structure, either by sinking the pier without them, or by withdrawing them after use. Nevertheless, there was a period of many years during which little or nothing was accomplished.

The recent activity in high building construction in New York City, however, making necessary a very extensive use of caissons of this type, has witnessed the substantial elimination of every material but concrete. The sinking of the coffer-dam and of a metal or timber roof for the working chamber, has been rendered unnecessary, and the steel shafting has been designed to permit its ready removal after it has served its purpose in the sinking of the caisson. These improvements have been put into practice in the foundations of the building for the United States Express Company, at the corner of Rector Street and Trinity Place; the New Trinity Building; the building for the United States Realty Company, at Broadway and Thames Street, and the Singer Building, on Broadway near Liberty Street.

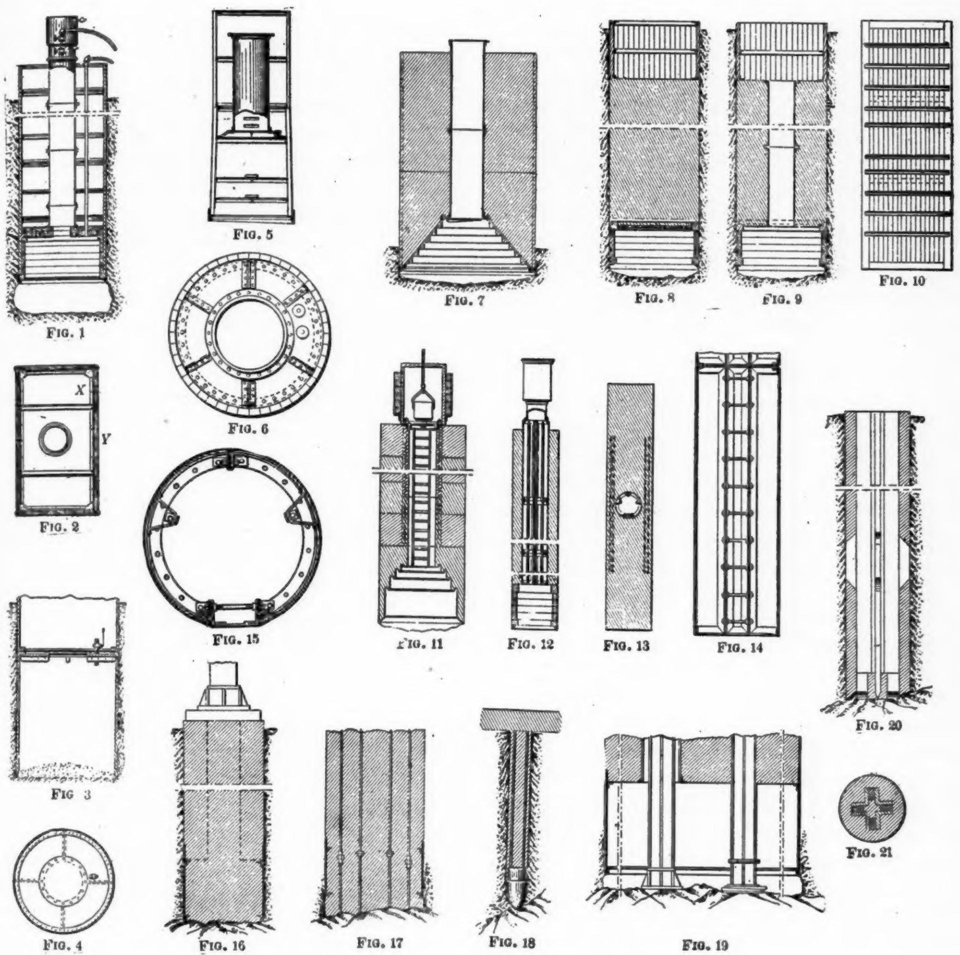
Elimination of the Roof.—The most serious objection to caissons of the style described has been the existence of the roof, constituting a dividing plane across almost the entire cross-section. The objection to such a dividing plane was appreciated from the earliest use of pneumatic caisson. The late Theophilus E. Sickles, M. Am. Soc. C. E., in 1870, and John F. O'Rourke, M. Am. Soc. C. E., in 1898, proposed the removal of the roof after the sinking of the caisson and before the introduction of the concrete above the working chamber.

The Sickles caisson is shown in Figs. 3 and 4. The roof consisted of four segmental plates bolted to the under side of internal flanges of the casing and attached to each other by bolts passing through radial flanges on the under side. After sinking to the required depth, and sealing the cutting edge with a sufficient filling of concrete to prevent the entrance of water, the air was cut off and the roof removed by withdrawing the bolts passing through the several flanges. The caisson of the type shown had a high roof and no separate air-shaft supported upon the roof, as in the modern type, the coffer-dam or outer shell being made air-tight throughout its height. For a caisson of this type, the design of the roof was probably entirely satisfactory.

The O'Rouke caisson, Figs. 5 and 6, utilized a similar roof in half-round sections, but the roof was bolted on the top of the inward flange of the casing, and the flanges connecting the segments to each other were at the top. This would permit the filling of the working chamber with concrete clear up to the roof before removing the latter.

The chief defect of these methods, however, appears in cases where, in order to get the requisite weight, the concrete is filled into the space above the roof during the sinking operation, as is usual in sinking through earth for building foundations. In such operations it has been impossible to eliminate the roof of the working chamber until the introduction of a recent improvement which, at the same stroke, eliminated the coffer-dam which had previously passed for a necessary evil in sinking caissons in earth. The feasibility of the improvement was first demonstrated by sinking all the caissons for the building for the United States Express Company by this method, and at a substantial reduction in cost.

Elimination of the Coffer-dam. There had been previously suggested, in 1904, the elimination of the coffer-dam and roof by sinking practically a solid pier of concrete, with only a central air-shaft and a working chamber hollowed out of the bottom. Fig. 7 gives a sufficient idea of the construction proposed. There was no distinction between different parts of the structure, except in so far as the lower portion of the concrete might be considered as the roof and sidewalls of the working chamber, and the concrete above this might be considered as the coffer-dam extending solidly from the surrounding earth to the shaft. It was proposed to build the whole of annular blocks of concrete laid one above another, or to form substantially a monolith by building up the structure *in situ* as fast as it was sunk. The difficulties in the way of moulding the concrete working chamber with suitably strong roof and sides and hardening it sufficiently in the short time available at the works then in hand prevented the utilization of this design,



PNEUMATIC FOUNDATION DEVELOPMENT.

and, instead, the contractors adopted the design shown in Figs. 8, 9 and 10.

The working chamber was built of heavy timber, and across the top were laid angle-irons, a few inches below which was fastened a temporary flooring. The steel shafting was supported on this flooring, and a roof of concrete was moulded thereon to a substantial height, and of the same outside dimensions as the working chamber. The earth being excavated, and the chamber sunk to a sufficient depth, another section of concrete was added The shafting was built up from time to time to maintain it above the concrete. After the first section of concrete was finished, the successive sections were moulded in place without interruption of the sinking operations, the excavation and the building proceeding of course at the same ultimate rate, but quite independently of each other, and the coffer-dam, reduced to merely a mould for the concrete, being removed before the sinking of each concrete section.

In a previous design, it had been proposed to divide each section of the coffer-dam into flat units which might be readily transported and only united to each other when in place on the next lower section, this method having the further advantage of avoiding the necessity of breaking the air-pipes (see Fig. 1), which had been a cause of delay with the use of sections which were completed before being put in place; and such flat units were now found to be excellent moulding plates, only four being

needed for each section of concrete, and excessive lengths being unobjectionable, because one might overlap the next at the corner.

The temporary flooring carried the concrete roof until the latter was hardened, and was removed before putting on the air pressure and the necessary lock. The angle cross-bars remained embedded in the concrete, transmitting its weight to the timber walls, although they were not necessary for the purpose after the concrete had hardened; and, in fact, after reaching a comparatively slight depth, the weight of the concrete was sustained by the skin friction and the air pressure, and added weights were necessary to force the caisson down. The cross-bars might have been designed and connected so as to permit their removal after the hardening of the concrete, if such removal had been thought of importance.

Only one accident occurred, and this demonstrated the advisability of using timber rather than concrete for the walls of the working chamber. The earth under one wall of the working chamber had been excavated previously to remove the footing of an old wall. When the first section of concrete had been moulded on this working chamber and the mould had been removed preparatory to sinking the concrete section, the old material replaced in the excavation allowed one side to settle so as to tilt the structure, and, before it could be righted, it fell over. The concrete was tied to the working chamber only by the crossing angles embedded in the base of the concrete, and swung bodily about the upper edge of a side wall of the working chamber, thus for a time putting its entire weight on this single wall. But the chamber was built so strongly that it was substantially uninjured, and the workmen in it at the time were unscathed. The accident, while indicating the necessity for greater precaution in building and sinking the first concrete section, demonstrated the practical excellence of the design.

When such a caisson was sunk to its final depth, there was no metal or timber roof to be removed. The cost of making first a sectional bolted roof, like that of Sickles or O'Rourke, and subsequently removing it, was saved; and, which is probably more important, the introduction of concrete above the working chamber did not have to await the sinking of the caisson. Its weight could be utilized in the sinking of the structure, and this weight, in caissons passing for a great depth through earth, is a very substantial consideration. It constituted probably the greatest of the series of advance steps under discussion.

Elimination of Shaft Lining.—The finished pier included, besides the concrete body, the cross-bars, which are a negligible consideration, being entirely embedded so as to prevent corrosion, and being of such slight cross-section as not to form cleavage planes in the concrete; and the steel shaft lining, which, at the very best, added not a pound to the load for which the pier might be safely designed, and, at the worst, might prove an element of weakness, and was certainly an element of substantial expense.

The progress of improvement in eliminating the shaft lining was the reverse of that in eliminating the roof. In the latter case, the idea was first advanced of making the roof removable after the caisson had been sunk; and the successful solution of the problem lay in avoiding the building of a true roof. In the case of the shaft lining, the first proposals endeavored to avoid its use entirely, but practical success came only with the idea of sinking the caisson with a shaft lining similar to those previously used, and removing the lining after sinking and before introducing the filling of concrete.

The first idea is shown in Fig. 11. A shaft-lining of moulded concrete is shown. To avoid excessive loss by leakage of air through the concrete, it was proposed to coat the inner surface of the shaft lining with air-tight material, such as a paint containing lime. The difficulty of connecting the shaft lining to the air-lock with sufficient strength to resist the upward air pressure on the latter was to be obviated by long tie-rods extending from the lock to the lowest section of the shaft lining, as indicated in dotted lines. It was also proposed in this design to eliminate the lining entirely, merely coring the concrete body and coating the surface with paint, as above, the manner of fastening the air-lock not being specified.

The first successful attempt to eliminate the shaft lining, however, involved the use of a removable lining, which, while casting more than those of common design, is usable again and again indefinitely, and, in the long run, effects a great economy. The design used in sinking the caissons of the new Trinity addition, and the adjoining building of the United

States Realty Company, is shown in Figs. 12, 13, 14 and 15. It was found that a comparatively small number of sections served for the sinking of many piers. There was no material loss of time involved in removing the sections and reassembling them for further use. In fact, the job was completed in much less than the previous record time for such work.

Figs. 12 and 13 show the shaft lining in place; Figs. 14 and 15 show the construction of one of the collapsible sections. Each section was composed of two approximately semicircular plates internally flanged for bolting to each other along one vertical edge, and a key interposed between the opposite edges of the plates. Internal flanges at the ends served for bolting successive sections to each other. Ladder rungs were arranged conveniently between the flanges of the key, and vertical guides were arranged just inside the line of the end flanges to guide the bucket past them. In some cases the tubing was made oblong in cross-section instead of circular. Packing was provided in all the joints, and this was the only part of the structure requiring renewal, it being cheaper to provide new packing for each re-use than to try to save the old.

Fig. 16 shows the finished pier, supposing the working chamber to be built of sheet steel. The dotted line indicates the joint between the concrete set up in sinking the pier and the filling introduced afterwards.

Comparison with Concrete Piles.—Side by side with the progress in caisson work, recent years have seen a rapid improvement in the sinking or building of concrete piles in the earth. The first attempt to substitute concrete for timber or steel in piles contemplated the manufacture of the concrete piles above ground and the sinking of them by one or another of the methods used for timber or steel piles. But, at present there are in the market several styles of concrete piles made by first forming the excavation and subsequently filling in the concrete. These methods permit the formation of piles of great depth and of theoretically unlimited diameter. Starting from widely-separated points, the two arts, caisson work and pile work, have constantly converged toward the same goal, a simple concrete column, bearing upon a rock or similar sub-foundation in the case of caissons and some piles, and supported by skin friction in the case of other piles.

The analogy has been carried even further by more recent improvements, in which vertical reinforcing rods of steel, similar to those sometimes used in concrete piles, are embedded in the concrete of the pier. The base of such a pier is shown in vertical section in Fig. 17, and Fig. 18 shows a concrete pile similarly reinforced. The reinforcing rods in the pier should extend down to the rock sub-foundation, and are most easily introduced in that method of construction in which the roof of the working chamber is omitted, turn-buckles being introduced for putting the rods under stress before embedding them in concrete. The non-adjustable flange joints may be used for the rods which run through the shaft, and substantially the entire length of which may bear freely on the sub-foundation before the concrete is filled in about them.

Most Recent Modifications.—The steel rods in the foregoing designs merely reinforce the concrete. Should the concrete fail, or be designed or built so as to shift a substantial portion of the load to the rods, the latter would be unable to stand the strain. A recent design includes the introduction of columns of sufficient strength to carry a substantial load. In fact, they may be proportioned to carry all or the greater part of the load. Fg. 19 shows the caisson sunk to rock, and the columns in place, ready to be filled with concrete. The columns are of ordinary style, built up of Z-bars riveted to a central plate. One column is embedded in the concrete from the beginning, and is wedged up at its lower end. This column may be duplicated as often as desired. Another passes down through the shaft, and is properly supported before its embedment. The shaft lining may or may not be withdrawn, as desired.

Since it is possible to carry concrete piles in many cases to a rock sub-foundation, where they act as true columns, the idea has been conceived of substituting steel, with its immensely greater strength as a column, and surrounding it with concrete, which stiffens the column to some extent, but which performs the principal function of protecting the steel from corrosion. The finished pile or column is indicated in Figs. 20 and 21. The column is hollow, which serves to carry a water-jet for sinking the column itself, and has a surrounding shell, which is afterward filled with concrete around and within the center

of the column. The shell may be withdrawn as the concrete is introduced. The column may be shod at its lower end so as to secure a good bearing by ramming it down on the rock.

Invention is largely accidental, and its progress is apt to be most erratic. The writer has never observed a series of improvements progressing more logically and consistently in the same direction than those here considered. The engineering profession owes to Daniel E. Moran, M. Am. Soc. C. E., and John W. Doty, Assoc. M. Am. Soc. C. E., who conceived these improvements, and to the Foundation Company, by whom they were put into practice, a very large debt for the originality and progressive spirit with which they have met the demands of modern builders for economical methods of providing foundations of maximum bearing strength.

Spotlessly pure marbles of the island of Paros, Greece, are mined by an English company. Many of the celebrated statues left by the ancient world were sculptured from the marbles of the Parian mines. The green marbles of Tinos and the red of Mani are likewise controlled by foreign capital.

CAISSON DISEASE EXPERIENCES AND RECORDS

The following has been compiled by John E. Owens, M. D., Chief Surgeon of the Illinois Central and Chicago & Northwestern Railways, appearing originally in *The Contractor.* The first observation in caisson disease where compressed air for submarine work was applied, was made in 1820 by Dr. Hamil of Russia. In the course of the great engineering work done, diving bells were employed. Dr. Hammil took great interest in studying the effects of compressed air, not only upon the workmen, but also upon himself. In describing his own experience, he states that at the depth of five or six feet severe pain was felt in the ears, which was relieved in a measure by swallowing. At fifteen or sixteen feet there was a noise in the ears like an explosion, followed by entire relief from pain. His respiration was perfectly easy. The ascent was accomplished with much less inconvenience than the descent. He states that one of the workmen became so accustomed to the air of the bell, as to be uncomfortable under the usual atmospheric pressure.

In 1822 M. Triger devised an air-chamber or a shaft that was sunk near the river Loire, France, for the purpose of reaching coal underlying a quicksand sixty-five feet, thick, and full of water percolating from the adjoining river.

The apparatus consisted of a steam engine, two air pumps and an air vessel. The air vessel had a stuffing-box fixed to its lower part, intended to connect it with a wrought-iron pipe, in such a way as to cut off all communication with the outer air. A supply pipe for the conveyance of compressed air from the pumps to the shaft, and an outlet pipe for the discharge of water, was added. Two man-hole valves, designed for passing men and material into and out of the air vessel, two air locks, a pressure gauge and a safety valve, completed the apparatus.

J. Hughes, assistant engineer at the Rochester bridge, England, noted that the men at work in the compressed air had a remarkable increase of appetite for food. Respiration, he said, was "slightly affected," and when the transit of the air-lock was rapidly made, there was some complaint of headache. The greatest depth under water was sixty-one feet.

Boinet says that effusions of blood are habitually observed in caisson disease. He also assigns as a cause the formation of gas emboli in the vessels, due to a too sudden decompression. He quotes Lorraine Smith, who speaks of toxemia which is produced by the oxygen accumulated in the air under high pressure; but Boinet believes that the pressure in the caisson is not high enough for the oxygen to become toxic. Paul Bert attributes the condition to bubbles of gas in the capillaries and the internal organs.

Boinet further says that we must take in consideration the predisposing conditions of men employed in the kind of work under consideration of such as age (over 45), pulmonary affections, fatigue, alcoholism, a meal, especially when large, before the emersion. We must also take under consideration the depth of immersion and the rapidity of the decompression.

The divers should know of the two most

important premonitory signals, viz., special pains, and temporary paralysis.

Of the sixty-four men employed in a caisson on the banks of the Loire in 1884, sixteen had severe attacks, and it was necessary to discharge twenty-five on account of sickness. Two cases resulted fatally. Very often, when life is not lost, the ensuing paralysis is permanent.

Albert Smith records the effect of high atmospheric pressure on the body as follows:

1. The pitch of the voice is changed from a bass to a treble and protracted conversation becomes very fatiguing.

2. The effect on the cutaneous vessels is shown by the pallor of the face, which is very marked, and continues for fifteen or twenty minutes after leaving the caisson.

3. During the work in the Brooklyn bridge caisson, when the pressure was about thirty-two pounds, he took the temperature of seven of the men an hour and a half after entering the caisson, and found that it averaged 99 degrees F. At first he accepted this as a result of the increased interstitial change so strongly insisted upon by Dr. Jaminet of St. Louis, but subsequent observations led him to interpret it differently.

The temperature of the body in health is kept at about normal by constant evaporation from its surface, but in the caisson, as already mentioned, the air was already nearly or quite saturated with moisture, so that evaporation from the surface must have been practically suspended. With the temperature of the air at 76 degrees F., as it was at the time of the observations, and the men engaged in severe labor, it is easy to see how the absence of the cooling process of evaporation from the surface would lead to a rise of one degree of temperature.

4. Circulation: Upon entering the caisson, the pulse immediately rises to 120, but gradually falls back to its normal standard, and sometimes below it.

The effect of high atmospheric pressure upon the volume of the pulse is always, according to his observation, to diminish it. This is easily accounted for by the pressure exerted upon the artery, which prevents its yielding readily to the expanding of each successive wave of blood. Hence the pulse is small, hard and wiry.

5. Upon the Perspiratory Function: Several writers have observed that it is immediately remarked by every one entering a caisson that the secretion of the skin is apparently immensely increased, noticeable even when the temperature of the air is moderate, but as this increases it becomes a very serious annoyance. The clothing quickly becomes saturated, which, besides the discomfort it occasions, exposes the wearer to great danger of taking cold on going into the open air. But a little examination served to show that in the Brooklyn bridge caisson at least there was really no increase of the secretion from the skin, but instead of evaporation, there was an accumulation of moisture, simulating excessive sweating upon the surface.

6. Upon Digestion: Nearly all authors who have written upon the effects of compressed air, agree that, for a time at least, it increases the appetite to a remarkable extent. Indeed, this is one of the first and most favorable results observed where compressed air is applied remedially. It was frequently remarked by the men working in the New New York caisson of the Brooklyn bridge, that their work made them unusually hungry, and that they could not get enough to eat. Of course it was not possible to obtain any exact data as to the relative amount of food consumed, but from careful inquiries it was considerably in excess of what is usual in the case of men engaged in similar labor in open air.

Jaminet, in his observations at St. Louis, found that the amount of fluid secreted by the kidneys was very much increased, in some instances nearly doubled, while the specific gravity was little if at all below the usual average. This shows that the solid matter excreted was also in much greater quantity than usual.

Corning has studied a number of cases of caisson diseases in the workmen employed on the Hudson River tunnel. The most common symptom, and usually the initial one, was pain, followed by loss of power and anesthesia. These may continue and other symptoms develop, presenting the picture of acute myelitis and cerebral symptoms may sometimes follow. The first ones are relieved if the patient at once returns to the caisson. The symptoms are considered to be due to the abrupt transition from an atmosphere of a high density to one relatively rarefied, as has been felt in aeronauts who ascended to great heights, who

were immediately relieved when they descended to lower levels.

In 1861, Robert P. Brereton, an assistant engineer, engaged in the construction of the center pier of the Royal Albert bridge at Saltash, England, reported that during the time required for the installment of this pier, air-pressure reached forty pounds above the normal; usually the pressure was much less, as the water in the main cylinder was kept down by pumps. He observed that at first his men worked too long at a time and on coming out they were slightly paralyzed, but in two or three days they recovered. With three-hour shifts the men could continue to work for several months consecutively.

John Hawkshaw, the celebrated bridge builder, at the construction of the Londonderry bridge, where seventy-five feet pressure was experienced, noted some casualties, and that one of the effects produced by the air-pressure was that the joints of some of the less robust men began to swell.

Oliver, of Newcastle, (Eng.), describes an enormous caisson in which thirty-five men could work at the same time. The chamber was forty-five meters long. He says that the early symptoms during compression are, as a rule, an unpleasant sensation in the ears or a deafness. Other symptoms may appear immediately after leaving or several minutes or hours after.

The causes of caisson diseases are attributed, in general, to too long a stay in the caisson, too high pressure, or too rapid decompression. The less important symptoms are muscular pains, sometimes necessitating morphine hypodermically, bleeding from the nose or mouth, abdominal pains and vomiting. The grave symptoms are paraplegia, convulsions, and sometimes, though seldom, sudden death. Such elements as increase of the pressure, the degree of impurity of the air in the chamber or of that forced into it, duration of rest between hours of labor, the condition of health of employe, the rapidity of the decompression, contribute to the development of caisson disease. Oliver lays great importance on the factors of impure air, and rapidity of the decompression.

At the foundation of the Rochester bridge (Eng.) across the Medway, Dr. Hally experimented for the effects upon four other persons. They remained under water, at a depth of ten fathoms, for an hour and a half, in a diving bell improved by his own ingenuity; nor was it considered any limit existed as to the period they might have continued down with equal safety. A sharp pain in the ears, of short duration, was the only inconvenience acknowledged.

Dr. A. Jaminet has left a most interesting account of his experience. He was employed by Mr. Eads, engineer of the construction of the Mississippi river bridge of St. Louis, to take charge of all the men at work in the air-chamber, and to establish such regulations as in his judgment the well-being of the men demanded. A floating hospital was established in a boat lying just below the pier. Besides ordinary accommodations, berths were fitted up in which workmen could lie down during their hours of rest.

Dr. Jaminet had been a frequent visitor to the air-chamber, and had himself felt the peculiar effects of compressed air. He had been much interested in testing the familiar law regulating the boiling point of liquids, when under pressure, and in noting the effect of the compressed air upon himself and those who entered the caisson with him.

He had noted the men as they came from the air-chamber. Their appearance was pallid and they were cold. In some the pulse was quick, varying from 95 to 110, but somewhat weak; with others it was as low as 60. Without exception the workmen complained of fatigue.

The pulse always quickened on entering the air-chamber, though it soon fell to the normal, and even lower, in the course of a watch. On one occasion the pressure was 32½ pounds more than that of the atmosphere. He recorded the pulse himself and five other visitors as follows: Before entering, 81, 78, 78, 79, 79, 80. Temperature 56 degrees of external air. They were ten minutes in the air-lock. At the end of six minutes their pulses were 100, 88, 98, 86, 95, 90 thermometer 62 degrees; temperature in air-chamber 48 degrees. In twenty minutes all felt a marked exhilaration. At the end of two hours their pulses were 68, 70, 71, 69, 70, 72. Their chests expanded during inspiration normally. They spent 5½ minutes in the air-lock on their return, but they felt very cold. Thermometer fell to 37 degrees in four minutes. Before ascending stairs, pulses stood 69, 70,

69, 71, 68, 72; after climbing the stairs, 106, 104, 92, 94, 102, 99.

The air-lock was, as a rule, excessively warm when the pressure was increasing, and exceedingly cold when the pressure was diminishing.

Dr. Jaminet always complained of cold in the air-lock, returning, and severe epigastric pain about ten minutes after coming out.

On the day the caisson touched the rock (pressure forty-five pounds) he remained in the chamber two and three-quarters hours. While in the air chamber he felt well. In the air-lock, on his way out, he was conscious of a great loss of heat, and he suffered a violent pain in his head. The air was escaping very rapidly. The chief engineer was with him in the lock, and, as was usual with him the discharge-cock was wide open. At Dr. Jaminet's request the escape of air was stopped a moment; the time spent in the lock was, however, but three and one-half minutes.

With difficulty Dr. Jaminet climbed the stairs. His pulse was 110; he was suffering severe epigastric pain, and his strength was nearly gone. He went directly ashore on the first boat. With great exertion he managed to walk from the boat to his carriage, which was about 100 yards away, and climbed in. He was able to drive to his house, half a mile distant and stagger into his office, where in a few minutes he became paralyzed. For some time he could not speak, but he retained consciousness. Gradually he gained command of himself, but his suffering was intense, and for three or four hours he considered his life in extreme danger. It was over twelve hours before he began to move his legs. A little later he was able to walk, but he was feeble for some days.

He made several careful investigations upon the amount and character of the waste of the human system while in the air-chamber. He found that, invariably, an abnormally large amount of urine was secreted, and that it contained unusually large amounts of urea. He estimated the amount of urine secreted during the twelve hours from 7 a. m. to 7 p. m., on the average 28 or 30 ounces per man, and the quantity or urea was far in excess of that found in the urine of a healthy laboring man when working in normal atmosphere. The men drank water freely. They had liberty to spend their off-hours as they pleased, but the doctor requested them to lie down in the berths, provided for that purpose, for at least one hour, immediately on coming up. However, the men refused to obey the order of the physician as to the hours of rest. Each man was subjected to a rigid physical examination. All old hands deemed unsuited to the work were discharged and unpromising applicants were rejected.

A man whom the doctor had once rejected came with a friend, and entered the air-chamber without the doctor's knowledge. At the end of the second watch he was seized with severe cramps and paralysis and it was months before he fully recovered.

There were several other cases at the East pier, and one of them was very serious. The man was badly paralyzed and broken down. After lingering about a year he died. In the West pier a very bad case occurred under an air-pressure of forty pounds (ten pounds less than in the East pier). The patient was sent, with several others, to the floating hospital, but the case, however, resulted in death. The man was really unfit to work. He had been a hard drinker for the past year, though he declared he was sober the day he went into the air-chamber. He worked but two hours.

A boy had been smuggled in by a friend and was taken sick the first day. The next day the doctor sent him home, with the injunction not to return; but he came back two days after and entered the caisson. After the first watch he was attacked again, and did not recover for a month. On each occasion he was insensible when carried to the hospital. He was 20 years old and very slightly built.

In a period of fifty days there were fourteen cases of cramps and paralysis. Later, notwithstanding the physician's vigilance and care, cases of cramps and paralysis were of almost daily occurrence.

At the East pier men worked three watches of one hour each, distributed over twelve hours; pressure forty-nine pounds. On the first day there was one case, which resulted in speedy death. The victim had worked three months at the other pier, and had suffered no inconvenience. He was on duty from 8 till 9 o'clock, and felt well after coming up. As he had neglected to bring his dinner he was allowed to go ashore at 11:30 to get a meal. He, however, got nothing to eat, but drank in a saloon. He returned just be-

fore 1 o'clock, and worked from 1 till 2. On leaving the air-chamber he, in common with the rest of his gang, came through the air-lock in less than four minutes. He was taken sick in the air-lock and was unable to climb the stairs. He became unconscious while being brought up, and died two hours afterward.

It appears that the temperature in the air-chamber was unusually high. The external air was 66 degrees, and as no adequate cooling apparatus was in use the air from the pumps must have entered the caisson very much heated. On the following day the air-supply came through a coil of 150 feet of copper pipe immersed in the river. The temperature in the air-chamber then fell to between 60 and 70 degrees.

The doctor at once transferred the ice box to the air-lock, and enforced his rules strictly. in spite of the efforts to keep down the temperature, the men complained of the heat, and of being very tired on coming out, and, not infrequently, of having headache. As soon as a man complained of pain or numbness he was required to rest over one watch.

To prevent men reckless of danger from passing through the air-lock too rapidly, the size of the inlet and discharge pipes was changed, so that though the valve was wide open, the stipulated time could not be curtailed. One can imagine the imprecations bestowed on the slow coach by the men in haste to get out.

At least three-fourths of the cases that died, worked in the air chamber only one day, and mostly but a single watch of two hours. Of all those that died from the effects of compressed air, eight post-mortems showed the brain and the spinal cord were congested in all, and in most of them the interior organs of the bodies were also congested. There was no doubt as to the immediate cause of death.

An air compressor is an item which should never be overlooked in an electric substation of any considerable size, as the life of any electric apparatus depends to a very large extent upon its cleanliness. Having a small automatically controlled compressor and a receiver in which a suitable pressure is maintained, the air should be piped to various points where cocks should be provided and ready means for attaching rubber hose.

STEAM OR AIR FOR POWER HAMMERS

The accompanying table we reproduce from *The Engineer*, London, with the comments of *The Engineer* thereupon. All reliable contributions to our mass of engineering data are to be welcomed, and all may be of use in their place. It is rarely, however, that matter such as here presented is ever decisive of the question proposed, since no prepared conditions can reproduce these of actual and unpremeditated practice. The relative costs of steam and of compressed air consumed for doing certain work with the hammer really give little hint of the final costs of operation, since the condition perhaps most affecting the result is that a hammer is never operated continuously, and it is the constant expense of standing always ready and the delay and inconvenience of warming up every time the hammer is used which alone should often lead to the choice of air as the operating medium, entirely regardless of the actual cost alone of the air or the steam used. *The Engineer* says:

Although everybody is prepared to admit that compressed air possesses certain advantages over steam for operating power hammers, the sweeping statement sometimes met with that the former is the more economical in steam hammers is not confirmed by impartial investigation. Messrs. B. and S. Massey, the well-known firm of pneumatic and steampower hammer makers, have recently published tables which throw considerable light on the subject. The properties of steam and compressed air are so nearly alike that it is safe to say that the same amount of work can be done in a hammer cylinder by a given volume of each, measured at the same pressure. Thus, in the third lines of the two tables there are given quantities of steam and air respectively, each of which has a volume of 10,000 cubic feet at 60 lb. pressure per square inch. These two quantities will therefore be capable of doing the same amount of work in the cylinder. In column five are given the costs of obtaining, under certain possible conditions, the various quantities of steam or compressed air. Non-expansive working has been assumed, the work being in each case 86,400,000 foot-pounds, but the equality is substantially maintained, even if a considerable degree of expansion be used. Very slight expansive working is, however, possible in steam-

Table of Costs of Steam.

	1 Gauge pressure, per sq. in.	2 Weight of steam.	3 Volume measured at pressure given in column 1.	Data assumed.	5 Cost of coal, labour, and boiler maintenance. Labour and boiler maintenance are included at the estimated rate of 2s. per ton of coal used. Price of coal 10s. per ton.	Price of coal 17s. 6d. per ton.	Price of coal 25s. per ton.
	lb.	lb.	cu. ft.		d.	d.	d.
(I.)	30	2198	20,000		28·3	45·9	63·5
(II.)	45	1990	13,333		25·7	41·2	57·6
(III.)	60	1753	10,000	5 lb. of steam delivered to hammer per lb. of coal burnt.	22·6	36·6	50·8
(IV.)	80	1666	7,500	(Thus allowing in the case of a boiler supplying 7½ lb. of steam	21·4	34·8	48·2
(V.)	100	1579	6,000	per lb. of coal, for the condensation	20·4	33	45·6
(VI.)	125	1500	4,800	in the pipes of ⅓ of the steam supplied by the boiler.	19·4	31·4	43·4
(VII.)	150	1480	4,000		19·1	30·9	42·8

Table of Costs of Compressed Air.

	Gauge pressure, per sq. in.	Volume of free air at 60 deg. Fah.	Volume measured at pressure given in column 1. and at 60 deg. Fah.	Data assumed. Air taken in at 60 deg. Fah., and cooling again to 60 deg. Fah. after compression, and used at 60 deg. Fah.	Cost of power for compressing the air. 1.—Electrically-driven compressor. Average efficiency of motor 85. Price of current per B. of T.U. (K.W. hours) 1d. 2.—Belt or gas-driven compressor. Price of power per B.H.P. per hour. ·88d.	¾d. ·66d.	½d. ·44d.
	lb.	cu. ft.	cu. ft.		d.	d.	d.
(Ia.)	30	60,800	20,000	Single-stage compressor without water cooling 9·85 B.H.P. per 100 cu. ft. free air per min.	87	66	44
(IIa.)	45	54,132	13,333	Ditto, 12·6 B.H.P. per 100 cu. ft. free air per min.	99	75	50
(IIIa.)	60	50,800	10,000	Single stage compressor with water cooling 14·3 B.H.P. per 100 cu. ft. per min.	106	79	53
(IVa.)	80	48,300	7,500	Two stage compressor with water cooling and inter cooling 15·5 B.H.P. per 100 cu. ft. per min.	108	82	54
(Va.)	100	46,800	6,000	Ditto, 16·63 B.H.P. per 100 cu. ft. per min.	114	86	57
(VIa.)	125	45,600	4,800	Ditto, 18·6 B.H.P. per 100 cu. ft. per min.	124	93	62
(VIIa.)	150	44,800	4,000	Ditto, 20·2 B.H.P. per 100 cu. ft. per min.	132	99	66

COSTS OF STEAM AND OF AIR FOR DRIVING POWER HAMMERS.

hammer cylinders. With air the further difficulty presents itself that to obtain any appreciable degree of expansive working involves a large drop in temperature, to guard against which it is necessary to reheat the air—a costly proceeding with such machines.

From the data supplied in Messrs. Massey's tables it is seen that as regards the items of cost here given it is generally more economical to use steam than compressed air. For instance, if the figures for 60 lb. steam pressure be compared with those for 45 lb. air pressure—the latter being regarded by the authors as the most economical air pressure to work at—with reference to a works where coal is obtainable for 10s. per ton, and electric current cost 1d. per unit, or belt power 0.88d. per brake horse-power per hour, the cost will be as 22.6 is to 99; or, stated otherwise, the cost of steam driving will be less than one quarter of that of air operating. On the other hand, in a works which has to pay 17s. 6d. per ton for fuel and only ¼d. per unit for electric energy, or 0.22d. per brake horse-power per hour for belt driving, air comes out the cheaper. Broadly, however, it may be calculated that the cost of driving by steam and air will be about the same in a works where coal costs 25s. per ton and electric power ½d. per unit, or belt power 0.44d. per brake horse-power per hour.

An interesting feature observable in the tables is that the cost of steam decreases as the pressure increases, while with compressed air the reverse is the case.

PNEUMATIC TUBES FOR THE FACTORY

By Richard H. Libbey.

A problem which at the present is receiving more attention than in the old days is that of transporting tools from the tool room to the machinist. In a great many shops the machinist has to go to the tool room when any tool is wanted, and in other shops a helper is sent on the errand. A step higher than this is the shop where by pressing a button the machinist calls a boy who can do the errand. Another problem, which comes up when the idea of centralization of the various departments in different buildings is carried out, is that of transporting small articles from shop to shop, or between office and shops. A telephone order is likely to be misunderstood, and, in at least one large and modern factory, the motto, "Verbal orders don't go," is strictly adhered to. To carry the messages, drawings, orders, etc., back and forth boys are often employed, but boys are rather slow, and liable not to be on hand promptly when wanted. The solution of these problems is easily found in a pneumatic tube system. A tube is run to the various points which are to be in communication, and the article to be transported is placed in a carrier, which is forced through the tubes by air. Tubes from 2½ to 8 inches inside diameter are used for manufacturing plants, the smaller tubes for messages, drawings and the like as well as small tools, and the larger tubes for communication between various buildings.

There are two pneumatic tube systems in use, one being the pressure system, in which compressed air is forced into the tube behind the carrier, and the other is the vacuum system, where an exhauster is used which, as we say, sucks the carrier through the tube. The pressure system is preferable for shop purposes.

In the vacuum system two tubes, an outgoing and an incoming, are required. Besides these there is also an exhauster pipe which is tapped into the suction tubes and which runs to the exhauster. The pressure difference in the tubes is from 6 to 12 ounces per square inch, which will easily take a carrier weighing half a pound; but there is no reserve power to help to start the carriers if they get stuck in the tube. The horse power required depends upon the number of bends and the amount of service required. For half-pound carriers at pressures of 6 to 12 ounces per square inch an allowance of one-fourth to one-half horse power for each line is sufficient. The carriers travel at a speed of 1,000 to 2,500 feet per minute. This system assists in the ventilation; but 12 inches away from the end of the suction pipe no draft can be felt.

At the central station the terminal of the tubes is rather simple, the outgoing tube having a bell-shaped mouth and the incoming tube end being covered by a clapper which is forced open by the carrier. At the single or local station an air tight metal hood or its equivalent is used, and the outgoing or suction tube is tapped into it as well as the incoming tube. This system is illustrated by Figure 1. The clappers swing outwards so that the carriers can pass through easily, and the clapper closes the opening almost instantaneously the suction through the tube is not broken enough to prevent the passage of another carrier going in the same direction in the tube. This arrangement of the single stations lessens the amount of exhauster piping, as all the tubes can be tapped near the central station and the exhauster can be placed close at hand.

The pressure system requires an air pump or compressor, which compresses the air to the required pressure, and an air receiver which is simply an air-tight tank. This acts as a reservoir, assisting in maintaining an even air pressure, and minimizing the pulsation due to the strokes of the pump. It also assists in taking the moisture out of the air. As an air compressor and receiver is a part of the equipment of most of the plants that would be likely to put in a tube system, a reducing valve and a separate low pressure air receiver may be easily installed. Then the plant can be utilized at a slight additional cost. If the compressor capacity must be increased it is often better to put in another high pressure compressor and use a reducing valve to lower the pressure to that required for the tubes. Then the high pressure air would be reduced in pressure and discharged into a low pressure receiver, being piped from there to the tube terminal valves by ordinary wrought iron pipe. With two high pressure compressors the plant would not be left without compressed air in the case of anything going wrong with one of the compressors. When a compressor is used it is well to put

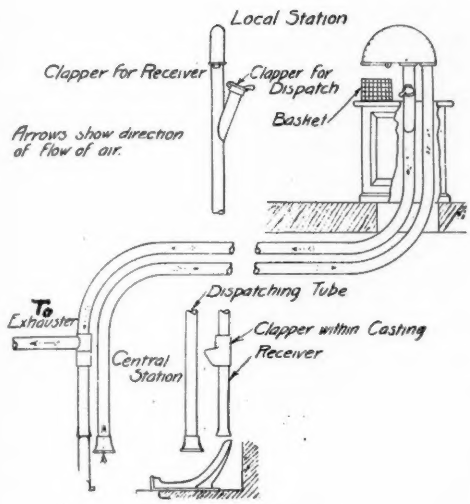


FIG. I. VACUUM SYSTEM.

in an automatic regulator also. By means of this regulator when a certain predetermined high pressure is reached the air will be by-passed around the piston so that the compressor will not be pumping against any pressure; or, by another scheme of regulation, the compressor will be stopped. When the pressure drops a predetermined amount the automatic regulator will start the compressor by closing the by-pass; or in the latter case by starting the motor or engine.

With the pressure system, which is illustrated by Fig. 2, the tubes are normally open to the atmosphere, but the terminal valves are so arranged that when a carrier is to be dispatched and the cover is closed it operates an auxiliary valve, which admits air under pressure behind the carrier. As the air supply pipe is smaller than the tube the air expands to a lower pressure if the carrier runs easily. If for any reason the carrier stops the air pressure rises until normal pressure is reached. If the carrier then fails to start the full pressure of the compressor can be turned into the line. This cannot be done with the vacuum system. When the carrier reaches the terminal for which it was dispatched it rushes out and, while doing so, actuates an auxiliary valve, which admits air into a small iron pipe noted as the releasing air pipe in Fig. 2. This pipe leads to a valve at the other end of the tube and admits air under a diaphram which is forced upwards, and in so doing unlatches the cover which by the aid of a spring or of gravity swings open. When it opens the air pressure on the main tube is shut off, thus preventing any waste of air and making an economical system, as power is being used during the passage of the carrier only. In the vacuum system there is a constant current of air. The auxiliary valve operating the unlatching or releasing mechanism is controlled by a dash-pot so that it shuts off the air just as soon as the diaphram has done its work. Instead of the auxiliary valve, pipe and diaphram arrangement a contact lever and an electro-magnet has been arranged in some cases and has been found to work satisfactorily.

While the pressure system requires only one carrier tube between two points of communication it does require that an ordinary iron pipe be run to the valves to carry the air to them. Two carriers at opposite terminals cannot be put in the tube at the same time as the outward rush of air at the terminal towards which the carrier is travelling would prevent the second carrier being dispatched. Usually the time of transmission is so short that no inconvenience is caused by the single tube.

The tubes for the vacuum system and also for the pressure system up to four inches inside diameter are of brass, hard brass tube being used for the straight runs and annealed

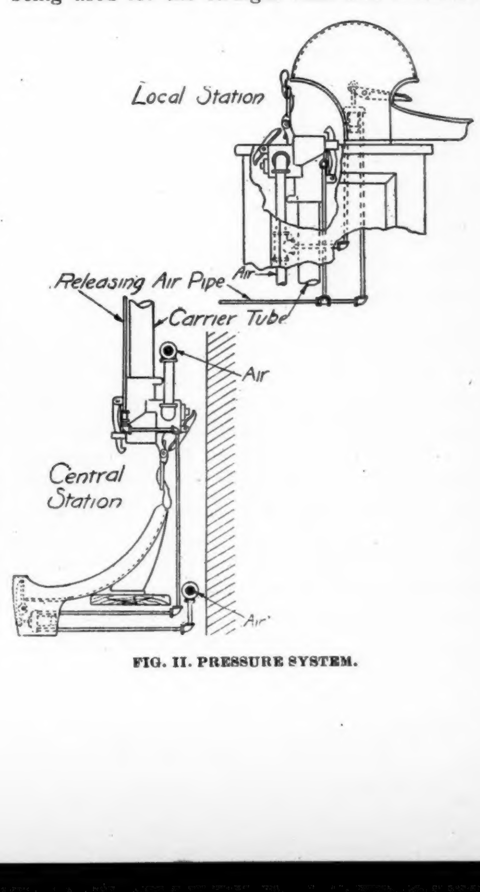


FIG. II. PRESSURE SYSTEM.

brass tubing for the bends. The tubes must be bent at a large enough radius so that the carrier can pass through easily without jamming, and all the joints must be flush and smooth so that there will be no sharp corners or burrs for the carrier to catch or rub against. When bending the practice of some manufacturers is to fill the tubes with melted rosin and allow it to solidify. After it has become thoroughly cooled and hardened the tube is bent over a form until the proper radius is reached. For tubes 2¼ and 2½ inches in diameter a minimum radius is three feet, and some use a larger radius, but three feet is sufficient for carriers of the ordinary length. After bending, the rosin is melted out of the tube and it is cleaned and polished. To test it it can be set up and a carrier dropped into it. If it goes through easily by gravity it can be depended upon as being all right. There are machines now in the market that can bend the tubes without being filled.

The straight runs are composed of a series of shorter lengths of tubing which are joined by a butt joint and over which a close fitting jacket or sleeve, also made of tubing, is clamped. This gives an air-tight joint, and one that cannot get out of line, as the jacket extends several inches each side of the joint. When the tubes are put up care must be taken to make a perfectly smooth joint and then there will be no trouble.

The eight-inch tubes are made of cast-iron pipe bored to the correct diameter. These are of the same form as the ordinary water and gas pipes, and the joints are made with yarn and lead in the usual manner. The bends are made of brass tubing. Two tubes, an outgoing and an incoming, are used, although the system is operated by compressed air. The terminals are more complicated than for the smaller tubes. The tube has a transmitter at one end into which the carrier is placed, and it is then tipped up, allowing the carrier to plunge through the clapper or gates and on into the tube. As there is a constant current of air the carrier is caught in the current and forced along at the rate of about 30 miles an hour at an air pressure of 9 pounds. At the receiving end there is an air lock arrangement that keeps the heavy carrier from banging into the terminal gates and receiver. With the smaller tubes the terminals are usually set vertical, discharging and receiving either upwards or downwards. With the larger tubes the receiving station is set horizontally. For obvious reasons the eight inch tubes cannot be bent at as small a radius as the little tubes, and this has to be taken into account when making a layout.

Carriers for messages are made of leather, open at one end with a felt washer or buffer at the other. For other uses the carriers are made of brass tubing with felt ends and a sliding cover in the side which allows the contents to be securely held in the carriers. The carriers for the larger size tubes are made of sheet steel with bearing rings near each end and a felt buffer at one end, while the cover is at the other end.

To even up all that has been said, it can be mentioned that the pressure system is the best for shop use, where tools and other articles are to be transported, because it has a reserve pressure which can be turned into the line to force any heavily loaded carrier along. With this system only a brass tube and a small iron pipe are required between two stations. If an air system is in use the only addition to the plant that is necessary is a reducing valve, and, finally with this system power is being used only when a carrier is in the course of transportation. With the vacuum system there is no reserve power to help out. Two brass tubes are required to complete communication between two stations. An exhauster must be installed and the system is using power continually. With both systems the air pressure is low and the valves are simple in operation and design, and there is no delicate mechanism to get out of order. The wear on the tube is so small as to be immaterial, and if by an accident a hole should be punched in the tube there will be no serious damage done. The outrush of air under low pressure will do no one any harm. Either system, when once installed, offers an economical, speedy and sure way in which the problem of transporting tools and small articles, as well as orders, messages and drawings to various points can be solved.—*Industrial Magazine.*

One astonishing discovery by the use of anchored balloons with self-registering devices at Strasburg, Germany, is an isothermal zone in the air at a height of about 40,000 feet, in which, contrary to experience in the lower regions, temperature does not diminish with recession from the earth.

COOLING AIR FOR COLD STORAGE

The following we abstract from *Ice and Cold Storage,* London. There is one main principle on which air is cooled for use in cold rooms of large capacity, but the methods of applying the principle are various. The principle alluded to is that of propelling air through a chamber containing some cooling agents.

The application of this principle in its simplicity is illustrated in Fig. 1, in which A is the duct by which air enters the cooling chamber CC. To force air into such a chamber and then to circulate it through a dozen rooms or more calls for some means of driving it along, such as a fan or air propeller fixed at a point, as F, just before the entrance to the cooling chamber.

The cooling chamber is arranged according to the following methods in the United Kingdom. In some cases two or more tiers of pipes, P P P, running lengthwise, are fixed in the chamber, a refrigerant being passed through them when the plant is at work. The refrigerant most commonly used is brine cooled to between 10 and 26 degrees Fahr. This wide range of temperature is of interest as presenting a phase of the working about which questions of economy arise. In some cases the cooling agent is a refrigerant in a vaporous condition. The cooling then is effected by "direct expansion," the refrigerant entering the pipes under conditions as regards pressure and temperature, which cause it to change from liquid to vapor, extracting heat from the pipes which confine the thus vaporized refrigerant, and from whatever may be in contact with them, which would be the air occupying the chamber. Whether brine, ammonia or carbonic acid were used the cooling principle would be the same; the air being in contact with the pipes containing the frigrant would be deprived of heat by them, and its temperature would be lowered.

Usually cold brine is also made to flow down over the outsides of the pipes, their entire surfaces being laced by the liquid. The brine prevents the accumulation otherwise of a deposit of non-conducting frost on the pipes, and also has a direct cooling effect of its own.

Another plan is the plate cooling method, in which pipes containing a refrigerant may or may not be used. The essential cooling media are plates, of thin galvanized metal, corrugated or flat, fixed either upright or on edge, with a flow of cold brine maintained downwards all over them, the aim being to maintain a thin film of brine on all the plate surfaces. In some cases the plates are three inches apart and sometimes more than this. The plates being usually lengthwise of the chambers, tthe air in passing through comes in contact with them, and is effectually cooled.

By a third method of cooling a number of discs of thin galvanized metal, two or three feet in diameter and either flat or slightly concaved, are mounted on spindles which rest across a tank on the floor of the cooling chamber to hold the cold brine, about one-third of

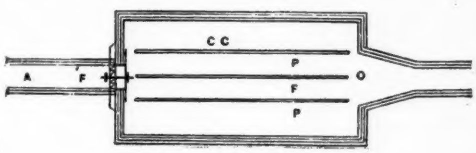


FIG. 1

the disc area being submerged. A slow rotation of the spindles keeps the discs constantly wet.

The spray method has as its chief feature the maintaining of a continuous shower of brine over the area of the cooling chamber. The fall of the shower may be direct or interrupted by a succession of perforated cross trays. The air driven through the cooler comes in contact with the particles of cold brine. A proper combination of pipes and plates makes a very effective cooler.

In the practical working of either of these coolers conditions may be noted which suggest modifications. The spray plan, for example, has at times produced very unfavorable results. The particles of brine have been carried away by the strong current of air and deposited on meat or poultry in the storage rooms.

In the construction of an air cooler, the surface area of the pipes, plates or discs provided for cooling the air blown through the cooler will, it may be assumed, be determined by the aggregate volume of the air contained in all of the rooms, and in the air-circulating trunks when the store is working at its maximum. In theory a known volume of air (*a*) may be cooled sufficiently to admit of a cold store working satisfactorily at its maximum,

by the said volume being kept in constant circulation through a cooler having a minimum cooling capacity (b). In strict theory, the determination of the ratio between the cooling capacity of the cooler and the cooling duty to be performed could be easily determined; but in the usual working of a cold storage plant variations are inevitable.

As already stated, the cooling agent may pass through the pipes at 10 degrees F. or at 26 degrees F., or at any degree between, and the brine showered over the pipes may show a like variation in temperature. Here, obviously, are factors which may interfere greatly with the theoretical ratio between (b) and (a), one is forced to provide for a compromise as between the theoretical ratio named and the ratio between the work actually to be done (c) and the efficiency of the cooler (d). This brings the enquirer to the practical conclusion that the most *effective* device for cooling air while passing *through* the cooler will prove at once the most economical.

Referring to Fig. 1, it will be obvious that if the space between any two tiers of pipes (P P) in a cooler be, say, twenty-four inches, the cooling effect of pipes of the same size, with the same refrigerant if twelve inches apart, would be much greater on the volume of air lying between the tiers. This suggests that, due regard being paid to the total efficiency of the refrigerant available for use in a cooler, the more tiers of pipes there are (where pipes are used) the better. The distribution of the refrigerant among the volume of the air contained in the cooler at any time will be the more advantageous, while the columns or "walls" of air between the tiers of pipes will be reduced in thickness.

In common practice the air enters the cooler at a particular point, say, the point F in Fig. 1, and is driven straight through the cooler, and passes out again by the outlet duct, O, at the other side. There is practically no hindrance or detention of the air in passing through. Obviously the air if held briefly in contact with the surfaces of the pipes, plates or discs, in passing through the cooler, would be more quickly and effectually cooled.

An arrangement which promises such a treatment of the air is shown in Fig. 2. In this case the lines P P P represent thin plates of metal (corrugated), the plates being fixed "on end," with their corrugations vertical and being not more than four inches apart. A thin stream of cold brine would be discharged from a perforated V-trough fixed across the top of each plate. With such an arrangement, the wall of air between each pair of plates would be sufficiently "thin" to admit of an expeditious cooling of the particles of air, while the on-

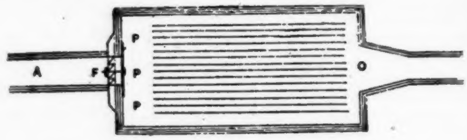


FIG. II.

ward motion of the air would be hindered somewhat by the corrugations, the cooling effect of the plates being hastened thereby. The arrangement of pipes and plates alternately disposed has the same effect. The reducing of the thickness of the columns or "walls" of air in the cooler, and the detention of the air for a longer time in contact with the pipes, plates or discs, while passing through the cooler, will give the most economic cooling of air attainable in ordinary daily practice at cold stores.

NATIONAL COAL RESOURCES

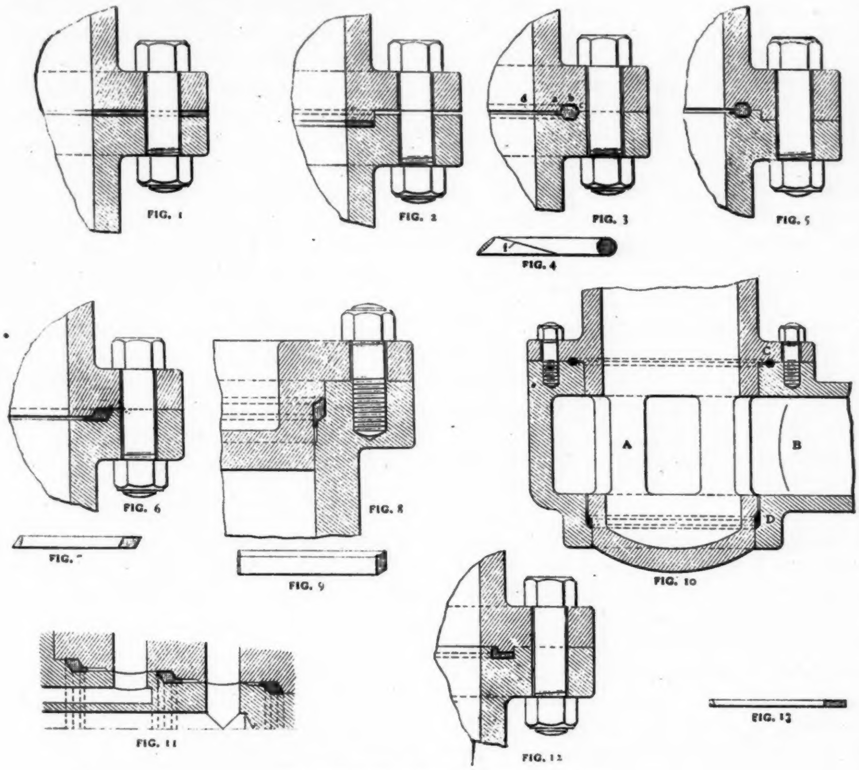
A government geologist, M. R. Campbell, has recently prepared an estimate of the bituminous coal deposits of the United States, not including Alaska, and his deductions should do much to quiet the alarmists who are predicting an early exhaustion of our fuel supply. From our present knowledge of the coal fields it appears that we originally had two thousand two hundred billion (2,200,000,000,000) tons, of which we have mined and used about seven billion tons, leaving a reserve of two thousand one hundred and ninety-three billion (2,193,000,000,000) tons. This does not include the anthracite fields, fields of low grade coal, or those of Alaska. Besides the deposits covered by the above estimate more coal is being discovered every year. A recent boring in Colorado passed through 34 coal measures, the lowest seam at a depth of 830 feet being 16 feet thick and of excellent quality. It is safe to estimate the present coal supply of the United States at seven thousand billion tons, and at our present rate of consumption, four hundred and twenty million (420,000,000) tons a year, we have enough to last us seven thousand years.

THE RAPIEFF FLANGE JOINT FOR HIGH AND LOW PRESSURES

By B. C. Batcheller.

Flanged joints for steam, water, air, gas and other fluids under pressure, are usually made tight by bolting a thin, flat gasket of some soft material between the faces of the flanges. Such a joint is shown in Fig. 1. The material used for the gasket is commonly rubber, compounds of rubber with other substances—asbestos, paper, lead, white-lead, etc. We depend upon the compression and flow of the gasket to fill the space between the flanges and friction to hold the gasket in place. Usually the gasket is made broad, covering the entire face of the flange, and the force of the bolts drawing the flanges together is distributed over a large area of gasket. It frequently happens, however, that the bolts must be screwed up very hard to give sufficient pressure per square inch on the gasket to make the joint tight; this is especially true if the faces of the flanges are rough or not parallel. As a result, flanges have to be made much thicker and bolts much larger than required by the longitudinal strain due to the pressure of the fluid alone.

In the case of high-fluid pressure it is common practice to increase the pressure per square inch on the gasket by making it narrow and not having it extend across the entire face of the flange. The gasket must be placed inside the bolt circle, and, as a result, if the flanges are not extra thick, there is great danger that the strain of the bolts will break them. A joint of this kind is shown in Fig. 2.



FLANGE JOINTS FOR HIGH PRESSURES.

FLAT GASKETS BLOW OUT.

It often happens with high pressures that sufficient friction cannot be obtained between the gasket and the face of the flanges, resulting in the gasket being blown out. This result can be prevented by placing the gasket in a groove or counterbore in the face of one of the flanges with a tongue on the opposite flange as in Fig. 2, but such an arrangement does not overcome the other objections to a flat gasket.

If the two flanges must be at a fixed and definite distance apart, the use of a flat gasket leads to much difficulty, since its thickness depends upon the force with which the bolts are screwed up. One part of the gasket may be softer than another, or there may be irregularities in the faces of the flanges, requiring the bolts to be screwed harder on one side than the other, in which case parallelism between the flanges cannot be maintained.

THE DYNAMITE GUN.

A great deal of ingeunity was expended about 15 years ago in designing the pneumatic dynamite gun, six of which were built for the United States Government, and erected for the defense of our harbors. The guns were eventually consigned to the scrap heap, but there were some features of their construction that deserve to live and have a prominent place among the useful devices of the mechanical arts. I have particularly in mind the method of making the joints in the pipes and castings that were a part of the gun and the gun reservoir. These joints were subjected to an air pressure of 1,000 pounds per square inch in the gun, and 2,000 pounds in the storage reservoir. They were easily and quickly made by ordinary mechanics and were invariably tight. The joints were designed by the late Captain John Rapieff, who designed the gun. One of them is shown in Fig. 3.

Just inside the bolt circle a groove of peculiar shape, *a b c*, is turned in the face of each flange, forming an annular space for the packing when the flanges are bolted together. Into the annular space thus formed, a ring of round rubber cord is laid, and the two flanges are bolted up metal to metal. The cross-sectional area of the grooves is made slightly less than the sectional area of the rubber cord, so that when the flanges are bolted together the rubber is slightly compressed into the form of the grooves and the surplus rubber flows into a narrow space *d*, between the flanges, that is open into the interior of the pipe. This space *d* is made about 1-16 inch thick. The fluid pressure acts against the thin lip of the rubber *c*, tending to force it back, putting the entire ring of rubber under static pressure, and sealing the joint at *c*. Thus the higher the pressure the tighter is the joint, which is not true in the case of a joint with a flat gasket. Since the flanges come in contact, there is no tendency to bend or break them in screwing up the bolts. The bolts need only be screwed tight enough to bring the flanges together, for the tightness of the joint does not depend upon the force with which the bolts are screwed up.

The rubber gasket ring is shown in Fig. 4. It is made from rubber cord that can be bought by the yard and made into rings as required. A splice is shown at *f*, which is made by cutting the cord obliquely and joining the ends with rubber cement. The ring should have the same diameter as the grooves in the faces of the flanges. Rubber cord ½ inch diameter is large enough for the largest joints, and it is not convenient to use cord much less than ¼ inch in diameter. The rubber should be of good quality, soft, and preferably what is known in the trade as "pure gum." When a joint is made in a horizontal pipe, the rubber ring can be held in the groove of one flange by means of rubber cement, while the other flange is being brought up into position. The joint shown in Fig. 3 was used when exact alinement of the bolted parts was not required. In joining together some parts of the gun—for example, sections of the barrel, alinement was important, and to secure that, the joint shown in Fig 5 was used, in which there is a counterbore and tongue.

USING A DIFFERENT PACKING RING.

Another form of the Rapieff joint is shown in Fig. 6, and a section of the rubber ring in Fig. 7. This has some advantages over the joint shown in Fig. 3, since there are only plane and conical surfaces to be machined instead of an irregular shaped groove. The rubber ring can either be molded or be cut in a strip from a flat sheet, and then made into a ring by splicing the ends.

The important point in making all of these joints is to have the section of the space for the rubber between the flanges slightly smaller in area than the section of the rubber before it is put between the flanges, and to provide a narrow space for the surplus rubber to flow into, which must be on the side toward the interior of the pipe. The rhomboidal packings and the conical surface *b c*, in Fig. 3, were made with an angle of 60 degrees.

Still another form of the Rapieff joint used in the pneumatic gun is shown in Fig. 8. This

shows a head bolted to a cylinder. The rubber packing ring is not placed between the flanges in this case, but within the cylinder and on the portion of the head that projects into the cylinder. In making this joint the rubber ring should be stretched over the cylindrical part of the head in order to hold in place while the head is being entered into the cylinder. The rubber ring should be wider and thinner than the space it is to occupy after the head is bolted up. Talc powder can be used to advantage on the rubber while sliding the head into place, to prevent the rubber from sticking. Fig. 9 shows the form of the ring before it is inserted.

PACKING TWO SHOULDERS.

With the flat gasket it is practically impossible to make two joints at two shoulders on the same piece and have them both tight, but with the Rapieff joint this problem presents no difficulties. An example is shown in Fig. 10. A lantern casting *A* is bolted by means of a flange to an annular casting *B*. To prevent the escape of fluid under pressure, a rubber-ring packing *C* is used at the joint of the flange, and a rhomboidal rubber-ring packing *D* in the cylindrical joint between the lantern openings. When the flanges are bolted together, both rings are slightly compressed. Fig. 11 shows an arrangement of several packings to separate spaces in the same castings.

The Rapieff joint is not confined in its usefulness to high pressures. In a modified form it has been extensively used in the Philadelphia pneumatic postal tube system, where the air pressure seldom exceeds 5 pounds per square inch. This joint is shown in Fig. 12. A rectangular groove, ½ inch wide by ¼ inch deep, is turned in the face of one flange, and a tongue ⅜ inch wide by 5-32 inch high, is turned on the face of the opposite flange. The outside diameter of the tongue fits the outside diameter of the groove. A rubber ring, shown in Fig. 13, ½ inch wide by ⅛ inch thick, is laid in the groove and the two flanges are bolted face to face. The rubber ring is compressed between the face of the tongue and the bottom of the groove until it has a thickness of 3-32 inch, the surplus rubber flowing into a space provided by making the tongue narrower than the groove. The advantages of this joint are the alinement of the pipe sections and the ease with which a rectangular groove and tongue can be machined.—*American Machinist.*

PREVENTING THE SPREAD OF DUST IN DRILLING SHOT-HOLES

Various attempts have been made to prevent the dissemination of dust during the operation of drilling shot-holes with percussion tools—a water-spray in one case, and oblique currents of air in another—but without much success. The Bonneway collector, illustrated in fig. 1, is said, however, to furnish good results, the dust being conveyed direct into a receptacle near the face, without escaping into the air at all.

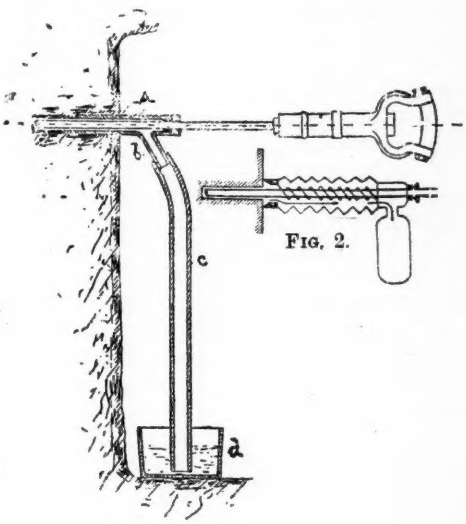


FIG. 2.

FIG. 1.

The collector consists of a tube A, about 10 in. long and 1¾ in. in diameter, which is driven into the mouth of the shot-hole when the latter has been drilled to a depth of several inches. The outer end of this tube is evased and fitted with a collar which presses on a rubber washer forming a stuffing gland for the percussion drill and preventing the escape of dust into the air, whilst at the same time helping to centre the tool. A downward branch *b* of the tube A is fitted with a flexible tube *c*, through which the dust is conveyed to a tub or other receptacle *d*.

Another device invented for the same purpose, by M. Lebacqz, fig. 2, has been in use for some time at the Bihain quarries. It consists essentially of a leather sheath, formed like the bellows of an accordion, to surround the stem of the drill, the one end of the sheath being attached to the drill stem and communicating

with a collecting bag, whilst the other end is pressed against the face by means of a spiral spring surrounding the drill stem. The folds of the sheath open and close with the reciprocating movement of the drill, the spiral spring keeping the face end of the sheath tight against the mouth of the hole all the time, the tension of the spring increasing as the hole is deepened.—*Annales des Mines de Beglique.*

CARE OF THE AIR BRAKE PUMP

In fast passenger service an air pump failure is an engine failure, and why the pump should not be given as much care and attention as any other part of the locomotive is not quite clear.

While pumping air into a leaky brake pipe has a tendency to overheat the pump, nearly all of the actual damage which results in a pump failure is done at the engine house at the time the pump is started. Nearly every hostler, shop hand or fireman knows how a pump should be started, but the way it actually is started is very often by opening the throttle wide, whether there is any air pressure in the main reservoir or not, and if the surge of water in the steam end of the pump does not break anything, the piston, after a few seconds, will throw the water of condensation out through the exhaust pipe.

If this same action took place in the cylinders of a locomotive in motion it would probably knock out a cylinder head, but as there is no pressure on the pump piston, other than boiler pressure transmitted through water it cannot knock the top head off. The worst it can do is to wash out all the lubrication of the top head and throw a strain on the bolts holding it, which usually results in a leaky top head gasket, and this robs the pump of the small quantity of oil that can be spared from the lubricator.

When a high air pressure is reached the discharge valves do not lift until the piston is very near the end of its stroke. The stroke shortens somewhat, as the high pressure checks the piston speed, thus giving more time for the reversing gear to operate. In order to be efficient the pump must deliver all the compressed air possible on each stroke. If it does not do this the air which is not delivered to the main reservoir will re-expand in the cylinder and occupy space that should be filled with fresh air through the receiving valves. It seems clear that if the stroke shortens after a certain pressure is reached in the main reservoir there must have been practically no clearance in the air cylinder while the air pressure was low. When the pump is started up fast with no pressure for the piston to cushion on it must strike the heads in order to stop its movement.

When a nut is rusted on a bolt, or drawn so tight that it cannot be loosened with a wrench, a hammer is generally used to pound the nut in order to loosen it and when a pump is started in the manner described there is no reason why the pound of the main piston against the cylinder heads should not loosen the nuts on the bottom of the rod, and the reversing plate bolts. If the end of the rod is burred so that the nuts cannot work off, the piston will be loosened in the air cylinder. It may not occur the first or the second time the pump is started in this way, but it will eventually loosen, and the steel rod will soon cut its way through the cast iron head.

The use of the oil cock and strainer is pretty well known, but there seems to be an impression prevailing in some quarters that the oil cock is a mere ornament, and that the strainer is intended to distribute about a pint of engine oil evenly about the inner walls of the air cylinder when the pump is groaning. There are several styles of oil cups used on the air cylinders of pumps some with an adjustable feed and some with a fixed feed. The former may be fairly well adjusted to feed the required amount of oil but the cup with a fixed feed is very unsatisfactory, as the air cylinder of a pump in good condition requires very little oil, while a pump that is pretty well worn requires much more. As a result of this the cup with the fixed feed partly stops up the ports in the air cylinder of the pump which is in good condition, and does not feed enough to the average pump to keep it from groaning. The piston rod should have a swab, and when the pump is oiled the swab should be oiled. The swab will prevent dirt and ashes from cutting and wearing the rod, and by lubricating the rod packing the swab will save several dollars' worth of packing on each pump in the course of a year.

If the pump is run at an excessive speed about the first disorder will be an overheated pump. This is very expensive. It not only reduces the capacity of the pump by causing

the packing rings and valves to leak, but scatters hot and burnt oil throughout the entire air brake system unless the main reservoirs are very large with a good piping arrangement.

When once hot the pump should be run as slowly as possible and kept oiled. Cooling the air cylinder with water is bad practice, as the cylinder is not of the same thickness all the way round and the temperature will reduce unevenly and be likely to warp the cylinder, which would necessitate reboring before new packing rings could be fitted, or it may result in the cylinder having to be thrown on the scrap pile.

A 9½-in. air pump can be run at such a high piston speed that the lift of the receiving valves will not allow the cylinder to be filled with air on each stroke. The partial vacuum thus caused in the cylinder reduces its capacity each stroke.

When the speed of the pump cannot be governed by instruction or discipline, or regulated by common sense, a copper gasket with a reduced opening placed in the steam pipe will prevent an unnecessary number of strokes per minute. Leaky air piston rings allow but a small volume of cool air to flow into the cylinder, and the "churning" of air is one of the common causes of a hot pump.

A blow through the steam end of the pump can develop at a number of places. About the only ones that can be heard on the locomotive are the top head gasket, the steam piston packing rings and a leak on the seat of the main slide valve. Leaks past the main valve packing rings, the reversing valve seat, and past the bushings usually stop the pump. It can then be started by tapping it lightly, and if the feed of oil is increased the pump may not stop again for several hours. When a blow is heard coming from the steam end of the pump it should immediately be given attention.

If a pump starts to pound after it has been in service any length of time and is known to be well lubricated, tight on the bracket and the bracket tight on the boiler, the pound usually comes from an improper lift of air valves, loose main pistons or lost motion in the reversing gear, and should be corrected at once or the pound will result in an air pump failure. When the pump is neglected until it does break down in service very little can be done by the engineer in an attempt to repair it. Cases have occurred where the nuts on the rod worked off in the air cylinder and were replaced while on the road, and where a bent reversing valve rod has been removed and straightened, but the nuts were not put on properly in the first place, and if the valve rod is a neat fit through the reversing valve bushing it cannot be removed without taking off the top head because the plate hammers a shoulder on the rod in a short time after it is put in, and, if a fit at the time, the burr prevents the valve rod from being pulled out. The burr can be avoided by filing the edge of the rod where the plate strikes it, but the repairman does not suppose that an attempt will be made to remove the rod when the engine is out on the road.

Sometimes a broken pump will make a stroke in both directions and stop at the bottom end, and if the steam is shut off and the reversing valve allowed to drop to its lower position, and the steam is again turned on, the pump will make another double stroke and stop at the bottom end.

If there is pressure in the main reservoir and the pump stops with a pound, it is usually due to a nut having worked off the rod in the air cylinder and blocked the main piston; if no pound can be detected it indicates a broken valve rod or a loose reversing plate. If the pump stops at the end of the up stroke with a pound it is usually due to a reversing plate bolt having worked out, although a piece of a broken air valve, or its seat blocking the air piston, will have the same effect. If the pump stops on the up stroke without any noticeable pound the trouble is usually in the top head. When the pump stops on account of insufficient lubrication it stops on the up stroke, with the main valve resting against the cap at the large end, which would appear to be the proper place to tap the pump, if necessary, to again start it.

The pump may become "dry" when it is not being used, and the main valve may have stopped in the opposite position. Opening the drain cock in the lower end of the steam cylinder will show on which stroke the pump has stopped.

When a pump apparently in good condition is reported to be stopping out on the road, and is known to be getting dry steam, and that there are no leaks in the steam pipe,

top head gasket or in the pump governor past the steam valve, which would waste oil through the drain pipe, it is good policy to replace the top head of the pump with one known to be in good condition.

When the head is renewed under these conditions, the packing rings in the air cylinder should first be tested by running the pump against an air pressure with the bottom cylinder head removed. The air valves should be examined and cleaned and the packing rings in the steam cylinder tested after the top head has been removed.

This can also be done in case the pump is due to be removed for inspection and repairs and if there happens to be no pump to replace it. In addition to removing the top head to inspect the gasket and reversing plate, particular attention should be given to the thickness of and the opening at the ends of the main valve packing rings; also to the wearing surface of the slide valve and its seat and to the reversing valve and bushing. Intelligent care of the air pump is often the means of avoiding an engine failure.—*Railway and Locomotive Engineering.*

REFRIGERATION IN MINING WORK

Mechanical refrigeration is used for the freezing of loose ground in quicksand soils to facilitate sinking colliery shafts, in running tunnels, in putting in foundations wherever the mass of water is too great to be pumped, or in cases where the removal thereof would damage existing foundations. It is, the especial object here, to consider the various advantages and disadvantages of refrigeration under special conditions, and also to discuss briefly the different types of refrigeration used.

In a general way excavation can be accomplished by the use of compressed air. Caisson work in the laying of foundations under water, or in excavating tunnels is a typical example. In nearly every case mechanical refrigeration competes with this, and it is largely a question of special conditions and relative efficiency which determines the use of the one or the other.

Certain extreme cases in both developments have such a degree of efficiency that they each practically eliminate the other type. Thus, in excavating where there is a comparatively rapid flow of water, as in the setting of bridge foundations or in tunnels under rivers, compressed air is superior by reason of the fact that the rapidly moving material would carry off a large portion of the partially frozen product and limit the efficiency of the pipes.

On the other hand, the depth at which compressed air can be used efficiently in excavating work is dependent more upon physiological conditions than upon mechanical or engineering ones. Beyond a certain depth the air pressure under which operatives must work becomes so injurious that the shifts must operate smaller and smaller units of time. The necessary loss in compressed air during the process of shifting and in ventilation, which becomes more inefficient in practice with higher pressures, limits the depth at which cassion work can be carried on. This limitation is not present in refrigeration.

The choice of the two processes becomes largely a matter of judgment of the special conditions. In the case of quicksand in a well, a coil of pipes of a somewhat larger internal diameter than the lining of the well is usually sunk, and the quicksand frozen by a circulation of cold brine through the coil. The necessary excavation can then be proceeded with, and as soon as the lining is put in, the circulation of brine is stopped and the coil withdrawn. Facility in the withdrawal of the coil is often accomplished by the injection of steam to render liquid again the material in the immediate vicinity. This process is efficient in small units and is superior to the utilization of compressed air in the illustration given above.

Very small refrigerating machines of a special portable character are available for this work, and the construction of the freezing coils and their utilization is not a matter of serious difficulty. In tunneling the same type of machine can be used, but other methods have been employed. The same can be said in regard to the sinking of shafts through subterranean water beds and quicksand.

There are three processes available for refrigeration in this development. The one, which has been mentioned, is very satisfactory for small work in excavation of any kind, but is superior in vertical shafts. Another uses a cold air blast. This is often done in the driving of horizontal tunnels, and although fairly efficient, the process has been superseded to a large extent by the hydraulic press

operation in which a moveable shield or piston is forced forward by hydraulic pressure and the plates fastened on the interior of this piston inside of a sleeve which is slightly larger than the diameter of the finished tunnel.

When cold air was used it was generally produced by an amonia compression refrigerating machine, since the ordinary air compression machine producing refrigeration by the balanced expansion of the compressed air is very inefficient. The air was then driven into the shaft through an inner tube, much like an ordinary hot blast, and the residual air was carried out between this tube and the walls of the tunnel. Sometimes a portable partition was built across the tunnel, and the air of the interior cooled steadily by an iron coil inserted in the chamber and through which a cold brine was passed or in which ammonia was evaporated.

During the construction of a tunnel for foot passengers through a hill near Stockholm recently, this method was employed for driving through about 80 ft. of loose ground which possessed so little cohesion as to render the ordinary method of excavation impossible. After the refrigerator was run continuously for 60 hours the ground was frozen to a depth varying from 5 ft. near the bottom to 1 foot near the top. Under these circumstances the tunnel could be excavated during the day and the refrigeration carried on at night sufficient to permit steady progress with an operation of the machine ranging from 10 to 12 hours per day.

In sinking shafts for mining operations the Poetsch process is the most widely known. In its original utilization the Poetsch process was used to reach a coal bed under a considerable body of subterranean water. This heavy sheet of water gave from a single borehole a flow of 36,000 cu. ft., which rose about 6 ft. above the surface. A stand-pipe was built to stop this flow, but it was necessary finally to divert the water in order to sink the shaft. The process proved satisfactory in this particular development and the shaft was sunk to about 350 ft., with freezing necessary a large part of the way.

However, the device as it existed in the early days possessed many mechanical imperfections, with the result that its deterioration factor was large, and the cost of the original excavation about $160 per ft.

One or two modifications of the Poetsch process exist today, with the object of making the device more efficient, but they are all of the same general type.

In driving a circular shaft the device consists of a series of vertical pipes arranged around the circumference of a circle. These pipes are closed at the bottom, with an interior pipe extending from the top into the outer one to produce a steady flow of the refrigerating material throughout the entire length of the pipe.

In this respect the pipes are similar in construction to several modern types of steam superheaters used for injection into a furnace, and their operation analogous but reversible. These vertical shafts are connected by hollow spokes to a central receiving chamber for the ammonia gas, divided into two parts, forming receivers for the inflowing liquid ammonia and the outflowing ammonia gas, if ammonia is used, or for the inflowing and outflowing brine, if cold brine is the refrigerating agent. This whole device is then attached to a windlass or hoist and sunk into the shaft. Arrangements for cutting out individual spokes or vertical pipes are attached and the two pipes at the top from the central chamber are connected to a refrigerating machine. The device is then sunk into the quicksand, or water, or loose dirt, and the refrigeration commenced. When frozen solid a number of the spokes are disconnected and removed, and the interior of the shaft excavated. Lining is then put in partially between the spokes and the machine driven down farther, the lining being completed above the device. On attaining the lowest depth the machine can be removed piecemeal and the lining completed if desired, or necessary.—*Condensed from Mining World.*

A continuous railway brake has been devised by Messrs. Siemens, in which, while the brakes are applied as usual by compressed air, the valves are controlled electrically, and simultaneously, so as to avoid the dangerous shocks experienced under ordinary conditions. The controlling wires are combined with the air pipes in such a way that a single coupling suffices to complete both the pneumatic and the electric connections between successive trucks.

COST OF VENTILATION PER TON OF COAL MINED

Pennsylvania anthracite mines are, as a rule, decidedly gaseous, and to remove the gases thus generated in the workings, the fans must be run day and night regardless of whether coal is being mined or not; this causes the item of ventilation to be a constant source of expense. All air courses have to be carefully inspected before the miners are permitted to enter the workings. If there is a leakage along any airway the current will be short-circuited to the up-cast. To prevent such defects in the ventilation a force of bratticemen are employed to inspect brattice walls, adjust doors, build stoppings, etc.

In mines such as are operated in the Wyoming and Lackawanna valleys, the care given to ventilation is constant, for it is a matter of vital importance and safety to the men underground. The cost of maintaining an efficient ventilating system is high. The charges against ventilation are made up as follows: (1) Amount of steam used per month; (2) interest and depreciation on the fan and its drive; (3) oil, grease, waste, etc., used on the ventilating apparatus; (4) materials used in building the stoppings, brattice, etc.; (5) wages of brattice men and engineer. The total of all these items amounted to the following at one colliery:

$0.047 per ton of coal mined in 1902
0.049 per ton of coal mined in 1903
0.072 per ton of coal mined in 1904
0.082 per ton of coal mined in 1905
0.078 per ton of coal mined in 1906
0.081 per ton of coal mined in 1907

Engineering and Mining Journal.

A SUBMARINE SPONGE FISHING BOAT

In a recent issue of *La Nature* is described a special submarine contrivance designed by the Abbé Raoul, a vicar-general of the diocese of Carthage, to be used in the sponge fishing along the coast of Tunis.

The vessel is cylindrical with hemispherical ends. It is 16½ ft. long by 5 ¼ ft. diameter, displacing in salt water about 9½ tons, and is operated easily from within by two men. The weight necessary for complete submersion is provided by three tanks holding 140 gallons. Two of these are constantly full of water while the third, smaller than the others, placed in the center, is filled by the water pressure for descending and the water is expelled by compressed air when it is desired to rise to the surface. A leaden safety weight attached to the bottom may be released in case of necessity, when the boat will rise rapidly.

It is propelled by two oars of steel, fitted with slats which open when moved through the water in one direction and close when drawn the other way. They have spherical joints in the shell so that they may be moved in all directions.

The fishing apparatus consists of a rod projecting from the bow through a spherical universal joint. This rod bears at its end a pair of cutting pliers which detach the sponge, hold it and deposit it in a basket suspended just above it. The sea bottom is lighted by a cluster of electric lamps and the fishermen observe operations through strong windows. Electricity for illumination is furnished by a storage battery, and there is a telephone communicating with the surface.

A NEW TOUCH OF COMPRESSED AIR IN DENTISTRY

The porcelain inlay has been known in dentistry for a little more than fifteen years, and during this entire period dentists have been endeavoring to find some method of adapting the process to gold, which is the only known material suitable for filling a tooth at the biting edge, being malleable and ductile, while porcelain is brittle and breaks under pressure. It has now become possible to use the gold inlay, by means of which the patient is relieved of any but the least handling of a tooth under treatment, after the cavity has been prepared for the gold that is to fill it. Instead of hammering in the gold, as was the only process until a few months ago, the dentist now takes a wax impression of the cavity, from which he constructs a mold into which the gold is poured in a molten state, the resulting cast being the inlay, and of course a facsimile of the wax model. The inlay is slipped into the cavity, which it fits exactly, and is secured with cement. It was found impossible, however, to cast a gold inlay that would not shrink until the present process was perfected whereby pressure is applied to the metal in the mold by means of compressed air.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Established 1896

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PUBLISHED BY THE

Compressed Air Magazine Company
Easton, Pa.

New York Office—Bowling Green Building.
London Office—114 Queen Victoria Street.

Subscription, including postage, United States and Mexico, $1.00 a year. Canada and abroad, $1.50 a year. Single copies, 10 cents.

Those who fail to receive papers promptly will please notify us at once.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

Entered as second-class matter at the Easton, Pa., Post Office.

Vol. XIII. JULY, 1908. No. 7

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COMPRESSED AIR LEAKAGE

Those who read the letter of Mr. Tecumseh Swift on the above topic in our April issue, (and all should have read it) will be interested in the following, which fully explains itself. It is from the second quarterly issue of *Reactions*, published by Goldschmidt Thermit Company. We would only ask *Reactions* to tell us of *any* compressed air pipe line which has been welded and made air tight by the Goldschmidt Thermit process. The article referred to is here reproduced in full:

According to a reader of the monthly magazine COMPRESSED AIR, we are guilty of the crime of manufacturing facts and figures to make our process of pipe welding appear in a favorable light. The gentleman in question, whose name is Tecumseh Swift, quotes our article at length and comments on it as follows:

"The animus of this," (our facts and figures) "appears in the last sentence of the article:"

'It is to counteract these losses that many concerns are now butt-welding the pipe-joints in their compressed air and refrigerating pipe lines, thus producing a continuous line of pipe in which leakage is entirely impossible and the cost of maintenance eliminated.'

'Now, as to the loss by leakage. I have reason to believe that the above assumptions are exaggerations and that it is not so difficult nor so unusual as here represented to make piping airtight. The capacity of the usual air receiver represents about one minute's output of the compressor with which it is associated, and the piping capacity will not average any more than that of the receiver, or altogether it might be said that two minutes' working of the compressor would fill the entire system from atmosphere up to full working pressure, and then when the compressor is stopped at night and in the morning the air pressure is still found there, which is the not infrequent occurrence, it is easier to realize how little air has leaked away than how much.'

'A handy, cheap and reliable welding process, which Thermit undoubtedly is, would, for compressed air practice, need to be accompanied by an equally handy, cheap and reliable *unwelding* process, for *all* air piping is not permanently installed, and the butt-welding of straight piping would not in any case

eliminate the possible leakage, which occurs not in the run of the pipe, but in valves, stuffing boxes and other places where Thermit would not apply."

Now, we do not know who Mr. Tecumseh Swift may be, or what his qualifications are to pose as an expert in compressed air matters, but we are quite sure that we have some excellent reasons, backed up by excellent authorities, for disagreeing with him. Taking first, his statement that our estimate of the amount of leakage in a compressed air plant is exaggerated, we wish to quote the following from an article appearing in the April 23rd issue of the *American Machinist,* page 633: "A coal company told an erecting engineer that one of his firm's compressors which had been running some time, was not delivering its rated capacity. The machine was rated at 44 cubic feet per revolution; its normal speed was 70 revolutions per minute, thus giving a free air capacity of 3,080 cubic feet per minute. The compressed air was used mostly for driving pumps. From figuring the capacity of the air cylinders of the pumps, one of the coal company's men had concluded that the compressor was not pumping nearly its rated capacity. The erecting engineer got permission to make a test. One Sunday the pumps were all shut off and it was found that it required 32 revolutions per minute of the compressor to keep the air pressure up to 80 pounds; thus showing a leakage of 1,400 cubic feet of free air per minute, requiring at the steam end of the compressor about 120 indicated horse-power."

The above is from an article prepared by Mr. H. V. Haight, Chief Engineer Canadian Rand Co., and Mr. B. C. Batcheller, Chief Engineer of the Pneumatic Service Co., in which they recommend the use of special fittings for high pressure air installations.

We do not doubt that there are some plants where, as Mr. Swift states, leakage is reduced to a minimum, but we were speaking of the average plant, where, as a general rule, very little care is exercised in fitting up the pipe line.

Now, in regard to Mr. Swift's statement, that a "handy, cheap and reliable welding process" should be "accompanied by an equally handy, cheap and reliable unwelding process;" we claim again, that he misinterprets the general tenor of our remarks. While we were not speaking of the special installation with white enamel machinery and nickel plated fittings, neither were we speaking of temporary plants, like contractors' plants, which are constantly undergoing changes. We believe that there are a large proportion of plants in this country where compressed air is used, and where the piping, once installed, will remain in place. At least it should be the object of a plant to place the piping so that, when once installed, it will not require to be changed. The joints could then be welded, and a considerable saving effected in the cost of leakage, which would be limited to valves and cocks which are very easily made tight.

THE DRILL CONTEST ON THE RAND

Those who read the account in our May issue of the South African Mines Drilling Contest will be interested in the following letter addressed to the editor of the *Mining and Scientific Press* in correction of certain misconceptions of a correspondent:

Sir—In your issue of March 28 there appeared a letter on this subject written by one who signs himself "Mine Manager." The gentleman appears to have overlooked the fact that 40 per cent. of the holes drilled in the South African stope-drill contest were upcast holes. He says: "The entire contest was based on drilling inclined holes in a perpendicular face." This is not true, for out of the whole four days which each drill had to run, not over an hour was spent by any competitor in drilling inclined holes in a vertical face. This is certainly a very small part of the four days, and furthermore the inclined holes in question were upcast and not downcast holes.

The conditions of the contest were fixed by a joint committee (of which the writer had the honor of being a member) consisting of mine managers, engineers, and drill-manufacturers. Every effort was made to make the conditions equally fair for every type of drill and at the same time to prove the relative drilling power of each type under the different mining conditions found in the numerous mines of the Rand. The entries included six drills of the percussive type, three of the hammer type with air feed, one hammer drill with a screw feed, and two of the Gordon type.

It was on just such upcast holes as "Mine

Manager" considers ideal that the winning drill, the Gordon, did more than double the work of any other competitor. Numerous rules were made in order that no question might arise as to the justice of the results, but the main points were as follows: All holes must be over 36 in. deep; all holes must bottom or finish large enough to take the standard sticks of explosive; all holes were to be drilled approximately as indicated by the judges before the work started.

Each day's work on the surface consisted in drilling for one hour in each of the test blocks, three hours being spent on downcast holes and one hour on flat and upcast holes. Underground, one day was spent on drilling downcast holes in an overhand stope and one day in drilling upcast holes in an underhand stope. L. C. BAYLES.

AN INTERNATIONAL CONGRESS OF REFRIGERATING INDUSTRIES

Announcement is made of the first International Congress of the Refrigerating Industries, to be held in Paris, September 17 to 23, The French committee has invited other countries to participate. The United States Government has accepted the invitation, and delegates will be appointed to represent this Government. An American committee has been formed in part, having the following officers: President, Homer McDaniel, Cleveland, Ohio; vice-president, John E. Starr, 258 Broadway, New York; treasurer, John S. Field, Chicago, Ill.; Secretary, J. F. Nickerson, 315 Dearborn street, Chicago, Ill. The purpose of the congress is to bring together the leading experts and representatives of the various industries and enterprises in all countries in which refrigeration is used for facilitating the preservation and transportation of food products. The congress is divided into six sections, as follows: Section 1, Low Temperatures and Their General Effects; Section 2, Refrigerating Appliances; Section 3, The Application of Refrigeration to Food; Section 4, The Application of Refrigeration to Other Industries; Section 5, The Application of Refrigeration in Commerce and Transportation; Section 6, Legislation. Arrangements have been made for a documentary exhibit and a display of plans, models and small appliances. American manufacturers are invited to send exhibits. Of these, particulars may be obtained from the secretary of the American committee.

THE SAND BLAST IN THE FOUNDRY*

CLEANING CASTINGS.

On the subject of cleaning castings, it may be said that, until quite recently, this work has been done by means of pickling and tumbling; both of these methods are well known and reliable, but more recently there has been a strong demand for cleaning by means of the sand blast.

It is thought by many that a sand blasted surface will hold paint more firmly than the surface cleaned by pickling. Some two years ago, our attention was called to the use of sand blast tumbling barrels. These are adapted to cleaning comparatively small castings.

SAND BLAST.

This apparatus includes a supply of compressed air at 15 to 20 pounds pressure and an elaborate exhaust system for the continuous supply of sand and for the removal of fine dust. This fine dust has been difficult to control, but this has finally been accomplished by passing it through a wet scrubber, as it is called. This scrubber consists of a stack or trunk about 7 feet square and 25 feet high. This stack stands in a water-sealed base and is fitted with a series of wooden racks or slats, over which a flow of water is circulated by means of a centrifugal pump. These racks are so placed as to break up the passage of air through them. They offer a very large area of wet surface to the dust-laden air, and in passing through them the dust is practically all deposited on the wet racks and is washed to the bottom, from which it is removed from time to time. This wet scrubber receives the dust, not only from the sand blast barrels, but also from the regular tumbling mills and, while it is not strictly speaking an essential part of either, the total amount of dust discharged is so great as to constitute a serious nuisance if blown into the open air and, except in any isolated situations, some efficient dust separating device must be provided.

The work done by the sand blast barrels is very satisfactory in both quality and quantity, and the direct labor cost is no more than the cost with ordinary tumbling barrels, but the cost of installation and the cost of maintenance are both high. The installation of the

*From a paper by W. T. Hatch, May Meeting N. E. Foundrymen's Association.

sand blast barrels must, therefore, be justified by quality of the work done, rather than by its cost.

SAND BLAST FOR LARGE CASTINGS.

During the past year, the question of applying the sand blast to machine frames and other castings too large for the barrels was taken up—after repeated postponements on account of the dust nuisance, which, within the writer's observation, has more than balanced its advantages.

The question was not as to the merit of the sand blast, but as to the feasibility of taking care of its dust and dirt, and operating it under fairly comfortable conditions for the operator. The arrangement of this installation will be of interest, because we have made it successful to this extent.

The sand blasting is done in a room built within the cleaning room proper. This room is 15 feet square and 8 feet high. The work to be cleaned is suspended from an overhead tramrail with an electric hoist

A slot in the roof of the room allows for the proper placing of the piece to be sand blasted, and the roof of the room protects the hoist from any injury. The room is ventilated by means of a Sturtevant steel plate exhauster with 18-inch suction and discharge connections. This exhauster is run at 1,260 revolutions per minute, and gives a free circulation of air through the room. Air is admitted to the room from the opposite side and as near to the operator as possible. The intention is to supply the operator with ample fresh air and to draw the dust away from him. The space between the operator and the dust outlet on the opposite side of the room is some 10 feet, and gives time for the sharp sand to fall to the floor, so that only the light floating dust is drawn out of the room. The sand can thus be easily shoveled up and used over repeatedly. The dust is discharged through a wet scrubber, similar in principle to the one used for collecting the dust from the sand blast and other tumbling barrels. The fitting up of this sand blasting room, including its exhauster, its motor and wet scrubber, has been quite an expense, to say nothing of the power required to operate the sand blast and the exhauster; still the quality and quantity of work done with this apparatus are very satisfactory, and if it be admitted that sand blasting is necessary, I believe our installation must be considered a success. As in the case of the sand blast barrels, however, the cost of the installing, operating and maintaining the sand blast apparatus is high, and the quality of the work done, rather than its cost, must be the reason for its adoption.

REPAIRING A SIX FOOT STEEL MAIN UNDER THIRTY FEET OF WATER*

The pipe repaired supplies Jersey City with water. The portion under the Hackensack River is 11-16 in. riveted steel pipe 6 feet in diameter. When this pipe was placed it was brought to the river bank in about 28 ft. lengths each made up of four sheets. These were connected upon a staging carried across the river on floats. The pipe as connected was enclosed in reinforced concrete rings, which were made in forms and then slipped over the pipe and afterwards grouted, thus making a continuous concrete covering, the weight of the whole being just sufficient to sink it. This completed pipe was then sunk in a level trench which had been dredged in the bottom of the river. Shortly after the pipe was lowered and filled with water and before the ends were connected to the line it was discovered that a break had occurred and it was decided to build bulkheads at each end, force the water out by air pressure and make an examination from the inside. It was discovered that a plate had parted, making an opening about seven-eighths of the circumference of the pipe, the widest opening, 2½ in., being at the bottom. This was repaired by putting a complete ring of steel plate inside the pipe. The ring was made of five plates and secured in place by stud bolts.

A year or so later, or in 1904, another break in this pipe revealed itself by the sound of the rush of water which was plainly audible when passing over the river in a boat. A diver could discover nothing of the leak but the noise; the leakage, however increased until the loss was between five and six million gallons daily.

In the fall of 1907 a diver again employed reported that the stream coming from the pipe was of sufficient velocity and volume to force his body to one side when he passed in front

*Abstracted from a paper by A. W. Cuddeback read before the American Water Works Association.

of it; that there was a hole in the concrete covering on the side of the pipe about 10 in. square, and that the velocity was so great that he could not feel of the pipe to determine the character of the injury to the steel plates. The diver's description of the leak and the quantity of water being lost was evidence enough that repairs should be made at once.

A compressed air plant of sufficient capacity to handle the job, together with the necessary boiler power to operate it, was secured and set up on the west bank of the river. At about 400 ft. west from the break a 48-in. tee had been placed in the line when it was built, with a main line 48-in. valve on either side of it and a 48-in. valve on the tee; also a main line 48-in. valve on the east side of the river. This afforded means of getting into the pipe without cutting the main line. An air lock was obtained and fitted to the flange of the valve in the tee, the plant set up and got in working order. About 200 ft. east of the 48-in. branch, which afforded a means of entering the pipe, and therefore 200 ft. nearer the river and the break, was a manhole. As soon as the pressure was off the main line the cover was removed from this manhole, and another cover which had been previously fitted with a 3-in. tapped opening, through which a 3-in. nipple was screwed, was put on in its place. From this manhole a line of 3-in. screw wrought-iron pipe, which had been previously prepared in suitable lengths, was then connected and carried down the 72-in. pipe toward the break as the water was forced out of the 72-in. pipe through the break by the pressure of the air. This 3-in. pipe acted as a discharge for the water after the break had been stopped up, and no more water could be forced out that way, and proved of sufficient capacity.

On Dec. 1, 1907, the first move toward getting into the pipe to determine the nature of the break was made. The main line valve on either side of the river was shut down, thus isolating the river crossing, which is about 1,000 ft. in length. These valves were finally closed at about 2 P. M. After these valves were closed the 48-in. valve on the branch was opened and as much water allowed to run out this section of pipe through the airlock as would do so. Then the airlock was closed and the air compressor was started. No difficulty was met in forcing out the water until it got to such a level in the pipe that the air would escape through the top of the break. As soon as this point was reached the air escaped with such rapidity that no further progress could be made toward forcing out the water. Several schemes were tried before it was finally possible to plug up the crack sufficiently to hold the air and force out the rest of the water. It being in the winter time, it was exceedingly unpleasant to wade in water up to one's neck and by hand plug up the crack with clay. Large quantities of waste and gasket yarn were floated out on boards in the pipe and the crack partially plugged in this way, but this method was found to be slow and unsatisfactory. Finally the foreman in charge of the work waded out in the water in a diver's suit and succeeded in plugging up the crack with clay, after which there was no further difficulty in forcing out the water sufficiently to allow men to enter and examine the pipe thoroughly. It was discovered that the pipe had cracked about three-fifths of the way around, the crack being on top and open at its widest part from 3/8 in. to 1/2 in. This work took all Sunday afternoon, Dec. 1, all day Monday, the 2d, and up to 2:30 P. M. on the 3d, when it was possible to make an examination and determine the nature of the rupture in the pipe. At this time Jersey City was getting short of water and so the water had to be turned through this 72-in. pipe again, in order to maintain the supply, which was done at 6 P. M., Dec. 3.

The time for making repairs being limited to practically a 48-hour period, it was seen that it would be utterly impracticable to repair this break in the manner in which the first break had been fixed. It was concluded to put an internal ring in the pipe, making the ring, or sleeve, of steel plate. It took three plates 2 ft. wide by 6 ft. long. It was thought that the ends of these plates could be bent inwards at right angles for bolting together, but it was found that the steel would crack, so angle irons were riveted to the plates instead. The ring when bolted together fitted the interior of the pipe loosely and set-screws were put in at different points to locate the ring with an equal space all around.

Several materials were considered for filling between the sleeve and the pipe. A patent cement which will expand upon setting was one of the materials, but it was rejected as a filling, because of the time necessary for its

setting, which in that position would have been at least 24 hours before it would have been safe to let water come in contact with it. Lead in its usual form was rejected, because of the impracticability of pouring the joint completely and the fact that, even if it were possible to pour it, it could not be calked its entire depth. Lead wool was finally decided upon. This was selected, on account of the felicity with which it could be handled, the fact that it could be placed in the presence of water and that it could be calked in the entire depth of the joint.

After the first examination of the pipe was made the actual starting of repairs was delayed for several days until arrangement to supply Jersey City with water while the conduit was out of service were made, and the repairs proper were begun on Dec. 19, 1907. The water was turned off at 8:45 A. M. on this date, and the pipe finally emptied below the position of the break, the necessary tools, sleeve, materials, etc., gotten in the pipe by 6 P. M. During the night the sleeve was placed in position ready for the filling material.

After the sleeve was placed in position the center of the joint around the row of circumfrential rivets of the pipe and where the crack was located was thoroughly calked with ordinary gasket yarn smeared with clay, in order to prevent the water working in and getting around the layers of lead wool which were to follow and to act as backing for the first layer of lead. Then the filling was continued from each side with lead wool and thoroughly calked to within about 2 in. of the outside edge of the sleeve. This outside space was filled with strips of solid lead, 3 or 4 ft. long, which had been poured in molds the thickness of the joint and thoroughly calked. The work of calking in the lead wool was begun at 6 A. M., Dec. 20, and carried on continuously until finished, and the water again turned on about 7 P. M. of the same day, making a total time that the conduit was out of service approximately 36 hours. The pipe was tested for leakage when the water was turned on and found to be tight.

Special homemade calking tools were used in placing the lead wool in the joint. The men who actually made the repairs worked in two shifts of five men and foreman for each; two hours in and two hours out of the conduit, the same men working in this way from start to finish of the job. The men were all from the regular working force of the company and were selected for their known qualities of endurance, and to their faithfulness is due very largely the successful completion of the job in so short a time.

SOME TUNNEL SCHEMES

A TWELVE MILE TUNNEL.

It is reported that the Great Northern Railroad (Hill system) is preparing to bore a tunnel about twelve miles long through the Cascade Mountains, or the main part of that range. Two large forces of men are already engaged near Leavenworth, Wash., getting material together to build three large dams in the Wenatchee River to develop power with which drills and machinery are to be operated It is also stated that the Great Northern has arranged for the development of electrical power from the Chelan Falls for the operation of trains through the present tunnel in the Cascade Mountains, and later through the twelve-mile bore. This tunnel project has long been openly considered by the Great Northern Company, and engineers have thoroughly investigated and approved of the plan. Such a tunnel would give the road the most direct line through the Cascades down to Puget Sound waters, and also dispose of the tremendous mountain climb which must now be made.

A SIX MILE TUNNEL.

It is stated by Mr. Julius Kruttschmitt, general director of maintenance and operation of the Harriman System, that the 36,000 foot tunnel under a spur of the Sierra Nevada will be built in the near future. All surveys for this tunnel were completed some time ago under the superintendence of Chief Engineer Wm. Hood. The boring will be carried on not only from each end but also from several shafts, so that it is expected that the entire work can be done in three years. This tunnel will reduce the climb by nearly 1,000 feet and also effect a considerable saving in time. The total outlay is estimated at $10,000,000 which will be more than warranted by the reduced cost of operating.

SPIRAL TUNNELS.

An interesting piece of railroad engineering is now in progress near Field, British Columbia, on the main line of the Canadian Pacific Railroad. The original grade turn is 4.5 per

cent., and it takes three and sometimes four locomotives to push the transcontinental trains up the hill. The Kicking Horse Canyon is too narrow for loops, so a new line is being built which will cross the river and cut right into the solid mountain with a tunnel 16 ft. wide, 24 ft. high and 3200 ft. long which will make a complete spiral, or, more strictly, a helix, emerging at a point 70 ft. higher than the entry. By means of this and other tunnels the grade of the line in this neighborhood will be reduced to 2.2 per cent.

The originator of the spiral tunnel, William H. Cilley, an American engineer, by this means found a feasible grade up the Valley of the Rimac for the Peruvian Central Railway. The method was later employed for a similar purpose in the St. Gothard tunnel in the Alps.

THE AUTOMOBILE IN DEVELOPING MINING

Few people realize the important part automobiles play in modern mining affairs. Those who have been reading of recent boom camps in Nevada know that the automobile is one of the almost indispensable factors in the quick development of new districts. New mining camps are not generally found along railway lines and to reach them from the nearest railroad point sometimes requires several days' travel under tiresome difficulties and discouraging annoyances. Now, as soon as a new camp is discovered or a rich strike is made which causes a stampede, a line of automobiles is immediately established and travelers are taken from the railway train right into the camp with little less conveniences than are afforded on the best trains and in about as quick time.

As a factor in the rapid development of mining districts in the west the automobile is regarded as of great importance. Capitalists and their representatives have little time to waste in life and unless the showing is of the most encouraging nature numerous properties situated in districts remote from railroads, are passed by. Since the advent of the automobile in Butte nearly all of the principal mining districts of Montana have been brought within a day's trip of the big camp where mining investors and engineers make their headquarters while in the state. Hardly a day goes by without some local mining man taking a party of visiting engineers, experts and capitalists to inspect a mine in some remote part of the state and the trip is made one of pleasure as well as business.—*Butte Copper Age*.

ELECTRICITY AND COMPRESSED AIR IN MINING*

For driving the ordinary reciprocating air-compressor, the electric motor does not show up at all favourably. The steam-driven compressor has a very high efficiency, a good deal higher than that of a steam engine driving a rotating shaft; its excellence in this respect being due to the fact that a great part of the work transmitted from steam to air cylinder passes direct along the piston rod and not through the crank pin at all. This advantage is of course lost if the whole power used in compressing has to come from the crank shaft as would necessarily be the case if an electric motor were used to do the work. If air-compressing is to be done by a motor, a rotary compressor suggests itself, but a very high efficiency does not seem probable in this direction. Some tests described by M. A. Barbezat on a Rateau steam turbo-compressor, built by Messrs. Brown Boveri, of 400-horse power and delivering air at 71 lb. pressure, give an efficiency of about 70 per cent.

It has long been known that the transmission and distribution of compressed air for mining purposes is, in practice, extremely inefficient; but the full extent of the losses, due to wasteful use of air, leakages and inadequate distribution pipes (which are often under the control of unskilled men) has only recently been realized. The investigations of Mr. Hutton and Mr. Schweder have now established the figure of 28-i. h. p. in the steam cylinder of the compressor as that necessary to keep each 3¼ in. drill properly running. Of this from 5 to 6-horse power gets far enough to be indicated in the drill, and, according to Mr. Schweder, only 1.7-horse power actually reaches the rock.

The ease with which electricity can be dealt with, and the fact that a switch-board instrument can at once indicate the presence of leakage, have caused proposals to be made to distribute power electrically to small motor-driven compressors underground. This, however, only goes part of the way to meet the difficulty, and many attempts have been made to produce an electric drill; but, as might have been expected, no purely electrical percussion drill seems to have proved satisfactory. The Temple, so-called electric drill (The Temple-

*From a paper read before the Institute of Mining and Metallurgy by H. J. S. Heather.

Ingersoll Electric Air Drill) seems to get nearest to solving this problem. This is really a pneumatic drill driven by the reciprocating motion of two plungers operated by an electric motor. There are no valves between the drill itself and the two air chambers, and no clearances to be filled with air at every stroke. Comparative tests have been made by Mr. C. A. Chase, general superintendent of the Liberty Goldmining Company, Telluride, Colorado, on 3¼ in. air drills working at 100 lb. pressure, and the nearest corresponding Temple drill, the actual drilling done by the latter being slightly more than that by the air drills. Mr. Chase found that the air drills took 25-horse power each at the motor driving the compressor, thus agreeing fairly well with the results above quoted, and the Temple drills 5-horse power each. These figures are said to have been confirmed by Mr. Barnes in the Yak Tunnel at Leadville.

The author has not had an opportunity of seeing the Temple drill, and the particulars he has received do not go sufficiently into detail to enable him to express a final opinion, but the arrangement seems to him a most promising one, and as, wherever applicable, it should reduce the present costs of power for drilling by at least one-half, it certainly deserves to be closely looked into.

NOTES

In the past quarter of a century we have seen the air compressor rise from the status of a mere curiosity to an immense factor in economical engineering, and why? Because engineers have put energy, skill and money into the problem, and recognizing the necessity for volumetric efficiency, they have used every device to make the air-pump handle every possible ounce of air.—*F. A. Rider.*

Glacier ice is now delivered to some of the larger consumers of Lyons and other cities of Europe. There are so many railways in the Alps at present that it has been found profitable to gather this ice and transport it to the cities, where it is preferred to other ice because of its hardness and lasting qualities. This ice is blasted and mined in the same manner as stone is quarried.

At Rio Tinto, Spain, where pyrite smelting is now being done (in six furnaces), Parsons turbine blowers are used. Operated in tandem, they deliver air against 60 oz. pressure, and are said to be of high efficiency, economical, and satisfactory in all respects save that there is an extraordinary and enormous noise at the intake of the air, which is next to unbearable to persons having to work anywhere near-by.

Cutting the price down dangerously near to the actual cost basis when a little artificial lull comes along is very poor policy for the operator who wants to stimulate prosperity. Doing business without a profit is a thankless task, and one calculated to make the man who indulges in it miss opportunities for getting good business later.

In the matter of equipment don't overlook the fact that elevating and conveying devices are the cheapest carriers for all kinds of material, and that human pack-mules are the most expensive as well as the most refractory elements that the manufacturer has to contend with.

Coal by weight develops eight times as much energy as dynamite, and dynamite costs forty-five times as much as coal. One dollar's worth of coal would then develop as much energy as $360 worth of dynamite.

The H. K. Porter Company, Union National Bank Building, Pittsburgh, has recently taken an order for six of its 18-in. gauge air locomotives for gathering purposes in the mines of the Homestake Mining Company, Lead, S. D.

A five-inch ammonia pipe at the Manhattan brewery, Chicago, burst recently, killing two men who were calling on the engineer and seriously injuring the latter. The men were overcome by the fumes before they could reach a place of safety.

The protection of steel reinforcement by bedding in concrete has been investigated by the National Physical Laboratory of Great Britain, the tests showing that both bright steel bars and those, bedded in the concrete without removing the scale from them are thoroughly protected from rust, even though the concrete is covered with water several

times a week for a year and afterwards left in the open air for months.

A paint has been prepared to indicate excessive heat in machine parts. It is described as red when cool or normal, but when the painted part becomes warmer than it should be it turns black, the red appearing again when the temperature falls. The paint is said to be made by mixing mercuric iodide and cupric iodide with distilled water in proportions which vary with the temperature which it may be desired to indicate.

Prof. Hallock lectured recently before the Chemists' Club, in New York City on "Blaugas." This is liquid illuminating gas discovered by Professor Blau, of Germany, and while it is not manufactured in this country, it has found an extensive use in Germany, where it is sold by weight. A 22-lb. cylinder contains enough liquid gas to supply a 50-cp burner for four months if used four hours a day. Very small copper tubes, about the size of an electric light wire and just as flexible, connect the burners with the reservoir.

Paris underground railways now open for traffic have a length of 32 miles, out of a total authorized of 57 miles, work being in progress on all lines which are not yet in operation. The Metropolitan scheme includes two sets of rails parallel to the Seine, and serving the traffic of the central portions of the city, a circular line surrounding the city, and situated between the central quarters and the fortifications, occupying somewhat the position of the outer boulevards; and, lastly, two transverse lines at right angles to the course of the river. The portions of this system now in operation carry an average of 350,000 passengers daily. The other concession, called the North and South Railway, crosses Paris transversely from north to south, and has a total length of about seven miles, all of which is now under construction.

Considering the great amount of dynamite used in the mines in Butte there are comparatively few accidents from explosions or blasting. It is estimated that 15,000,000 blasts are set off in Montana each year. Careful estimates place the number of blasts in the Butte mines at 35,000 per day when the mines are operating at full capacity. About 4,800,000 pounds of explosives, 120 carloads, are used each year in Butte and the cost aggregates $720,000. Candles are sometimes used in lighting the fuse and this practice helps to swell the enormous amount of candles consumed in the big mining camp. It is estimated that five carloads or 1,000,000 candles are used each month in the Butte mining district, or 12,000,000 a year, at a cost of about $192,000.

A novel gas engine starter has been developed by the Oil City Gas Engine Co., consisting of a flash boiler furnishing superheated steam at high pressure which may be used in a gas engine in the same manner that compressed air is used for large engine units. The boiler is of the coil type of small capacity, and is heated by a large gas burner. When in operation, the coil is heated to a red heat, and then a small quantity of water is injected by a hand pump. This water instantly flashes to steam of from 400 to 500 pounds pressure, and is then admitted to the engine cylinder. The first heating of the coil will furnish sufficient steam for turning the crank a number of revolutions, and if the engine then should fail to get in operation, a second heating of the coil will give another number of turns, and so on. A Safety valve set at 500 pounds protects the device from excessive pressure.

The transportation of coal from the landing piers at the Genoa, (Italy) wharves has been considerably increased by the opening of a tunnel, cut through solid rock, and leading to the adjacent City of Sampierdarena. Coal trucks drawn by mules, which will hereafter pass through this tunnel, will supply fuel for the consumption of the different factories lying between the City of Genoa and Voltri on the west and Bolzaneto on the northwest. The dimensions of the tunnel are: Length, 275 meters (902 feet); width, 15 meters (49.2 feet); height, 8 meters (26.2 feet). Constructive work was begun on August 1, 1907. Trucks transporting coal save a long ascending passageway, involving more than an hour's time. Some 600 carloads, averaging from 2 1-2 to 3 tons of coal each, will pass through the tunnel daily. Its mouth begins on the pier, just under the fortress of San Benigno, and ends at Sampierdarena.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

MAY 5.

886,353. AIR-PUMP. ORRIS J. DARLING, Detroit, Mich.

886,390. SIPHONIC DREDGE. WILLIAM J. MONINGHOFF, Philadelphia, Pa.

886,402. CUSHIONING DEVICE FOR PISTONS. OTTO S. PIKE, Malden, Mass.

886,428. DUPLEX AIR-PUMP. JOHN SHOUREK, Pittsburg, Pa.

886,489. AUTOMATIC SHUT-OFF FOR PENUMATIC TUBES. EDGAR FLINT, Toronto, Ontario, Canada.

886,552. GAS-PRESSURE GAGE. WALTER THOMAS, Vancouver, British Columbia, Canada.

886,615. PNEUMATIC RECUPERATOR FOR RECOIL-GUNS. OTTO LAUBER and NORBERT KOCH, Essen-on-the-Ruhr, Germany.

886,699. ACETYLENE-GAS GENERATOR. JOSEPH HEATON, Hampton Station, New Brunswick, Canada.

886,834. PRESSURE-CONTROLLER. ANDRE MICHELIN, Paris, France.

887,051. FLUID-FEED SIDE-INLET DRILL-BIT. JOHN H. WIEST, Boulder, Colo.

MAY 12.

887,095. FLUID - PRESSURE - OPERATED TOOL. CHARLES H. JOHNSTON, Chicago Heights, Ill.

887,199. EXPRESSION DEVICE FOR PNEUMATIC MUSICAL INSTRUMENTS. EUGENE DE KLEIST, North Tonawanda, N. Y.

887,361. ELASTIC-FLUID TURBINE. ERNST P. WAGNER, Charlottenburg, Germany.

887,363. ROCK-DRILL. GOVERNOR D. WARREN, Cripple Creek, Colo

887,380. ELASTIC-FLUID TURBINE. CHARLES W. DAKE, Grand Rapids, Mich.

887,388. VACUUM POWER-HAMMER. LOUIS GOLLY, East Orange, N. J.

887,467. METAL-CUTTING BLOWPIPE. CYRILLE DELCAMPE, Bridgeport, Conn.

887,491. ACETYLENE-GAS GENERATOR. CHARLES W. METCALF, San Diego, Cal.

887,505. AIR-CUSHION AND AIR-COMPRESSOR FOR AUTOMOBILES AND OTHER VEHICLES. WESLEY H. NELSON and LEE W. GALLOWAY, Norwood, Colo.

887,571. AIR-COMPRESSOR. FREDERICH B. BABEE, San Jose, Cal.

887,608. APPARATUS FOR RAISING AND LOWERING LOADS. LOUIS E. A. DUFLON, St. Petersburg, Russia.

1. In an apparatus for raising and lowering loads, the combination with an elevator conduit and a compresesd air conduit of a plurality of loading cylinders adapted to successively register with the elevator conduit each provided with an air passage to connect the elevator and air conduit, means to vent the elevator conduit at a predetermined point to neutralize the pressure therein, and means in the conduit to engage a load raised above the venting means.

887,726. HUMIDIFYING APPARATUS. WILLIAM J. KELLEY, Central Falls, R. I.

MAY 19.

887,801. ROCK-DRILLING MACHINE. HENRY HELLMAN and LEWIS C. BAYLES, Johannesburg, Transvaal.

887,884. TRACK-SANDING MECHANISM. CHARLES P. WHITE, Greensboro, N. C.

887,925. SHOCK-ABSORBER. DAVID M. DAVIS, Washington, D. C.

5. In a device as set forth, a hollow member elliptical in cross-section comprising three chambers, a central chamber and two auxiliary chambers, a piston movable in the central chamber, said central chamber having air vents intermediate the ends thereof, the auxiliary chambers having communication with the central chamber in such wise that upon the upward stroke of the piston, the air is forced into one of said auxiliary chambers and upon the downward stroke, air is forced into the other auxiliary chamber, at the same time air is returned from the first-named auxiliary chamber in reduced volume upon the downward stroke of the piston while air is returned from the second mentioned auxiliary chamber in reduced volume upon the upward stroke of the piston thereof

887,931. AERIAL APPARATUS. CHARLES J. A. FIESSE, Washington, D. C.

887,955. COMPRESSOR OR BLOWER. RICHARD J. MCCARTY, Kansas City, Mo.

887,974. ART OF SMELTING ORE. ALFRED STEINBART, Pittsburg, Pa.

1. As an improvment in the art of smelting ore, the method herein described which consists in lessening the percentage of moisture in the air to be forced into the furnace to a point below that of saturation at atmospheric pressure and at the temperature of a natural cooling medium, maintaining the moisture at a slowly varying percentage below such point of saturation by subjecting the air to comppression and to such natural cooling medium and forcing the air into the furnace.

888,007. STARTING MECHANISM FOR EXPLOSIVE-ENGINES. HARRY C. FRICKE and GEORGE E. TURNER, Pittsburg, Pa.

1. In an explosive engine, the combination with the cylinder and piston, and means for supplying an explosive mixture thereto, of means for supplying a compressed motor fluid to said cylinder, a valve chest for said fluid supply, a cam operated by the engine, and a valve in said valve chest normally out of operative relation with said cam, said valve being constructed to be forced into operative relation to the cam by the admission of compressed fluid to said valve chest, substantially as described.

888,074. MEANS FOR STARTING INTERNAL-COMBUSTION ENGINES. GIOVANNI ENRICO, Turin, Italy.

1. In an internal combustion engine, the combination with the cylinder of inlet and outlet valves, cams for operating such valves, a hollow cam shaft carrying such cams, an additional valve adapted to admit comppressed fluid to the engine for starting purposes, a cam for operating said additional valve, said cam being independent of the outlet and inlet valve cams, and being adapted to slide on said cam shaft, and a second shaft for operating the cam for the additional valve, said shaft extending within the cam shaft and being connected to its cam through slots formed in the cam shaft.

888,126 VALVE MECHANISM FOR AIR-COMPRESSORS. THEODORE H. SMITH, San Francisco, Cal.

888,164. PNEUMATIC DRILL. MARTIN HARDSOCG, Ottumwa, Iowa.

888,189. AUTOMATIC TRAIN-PIPE COUPLING. NICHOLAS F. NIEDERLANDER, St. Louis, Mo.

888,207. FLUID-PRESSURE BRAKE. WALTER V. TURNER, Edgewood, Pa.

888,239. PNEUMATIC FLUE-EXPANDER. HARRY KELLY, Houston, Tex.

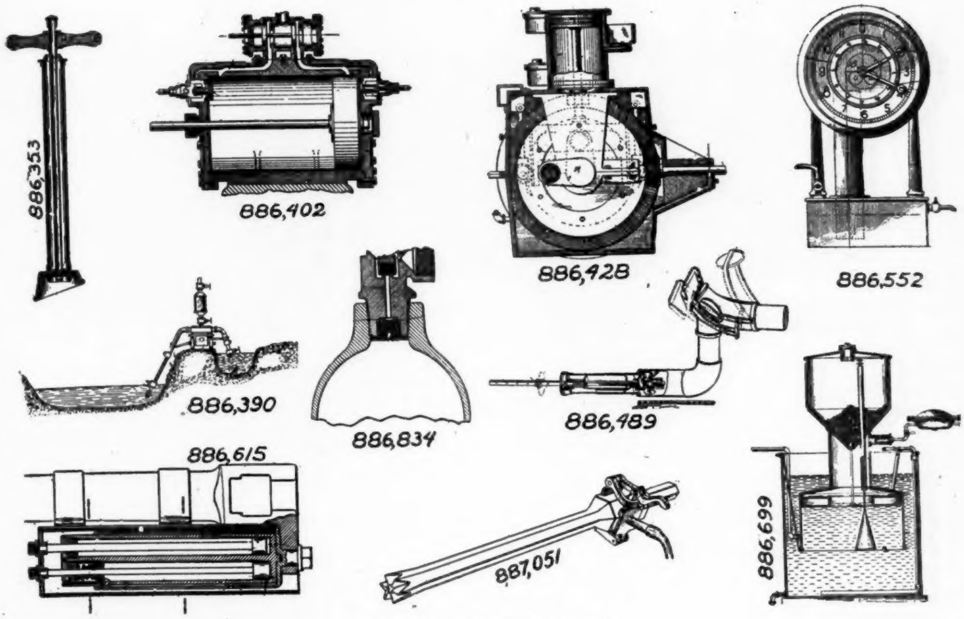
888,267. AIR-SHIP. JULIUS C. SANDRIK, South Bethlehem, Pa.

888,354. APPARATUS FOR ELEVATING GRAIN AND OTHER GRANULAR OR PULVERULENT MATERIALS. LOUIS G. ROHDE and HENRI J. ROHDE, Paris, France.

888,449. COLOR AND DYE SPRAYER. HANS MIKOREY, Schoneberg, near Berlin, Germany

MAY 26.

888,492. ROCK-DRILL. JAMES S. HARLOW, Mineral, Va.



PNEUMATIC PATENTS, MAY 5.

888,497. ROCK-DRILLING MACHINE OR ENGINE. HENRY HELLMAN and LEWIS C. BAYLES, Johannesburg, Transvaal.

888,506. TURBINE-DRIVEN ROCK-DRILL. MOSES KELLOW, Penrhyndendraeth, England.

888,553. AIR-COMPRESSOR. CHARLES P. TOLMAN, New York, N. Y.

888,565. POSITIVE-PRESSURE BLOWER. JOHN W. WILSON, New York, N. Y.

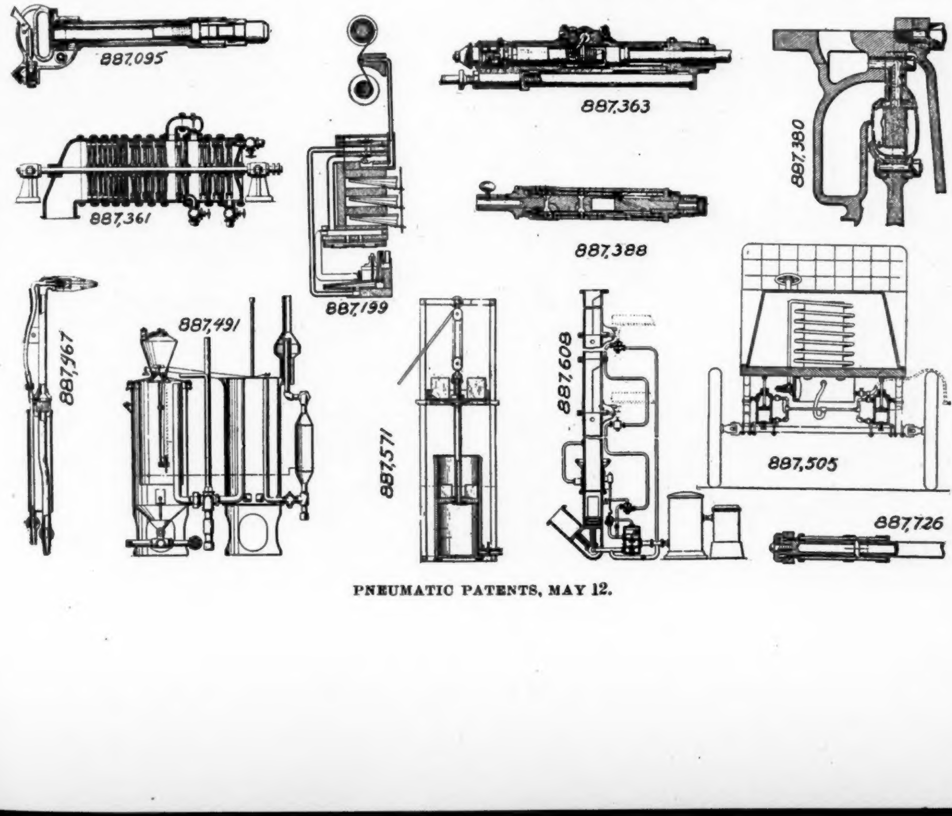
888,567. AIR-BRAKE. JOHN B. WRIGHT, Greensboro, N. C.

888,571. PNEUMATIC STACKER. LARS M. ANDERSON, Crookston, Minn.

888,762. AIR-PUMP. SAMUEL E. SPENCER, Springville, N. Y.

888,790 METHOD AND APPARATUS FOR CONSTRUCTING SUBAQUEOUS TUNNELS. BENJAMIN DOUGLAS, Grosse Ile, Mich.

1. The method of constructing subaqueous tunnels, which consists in building the same within an open bottom shield and in advancing said



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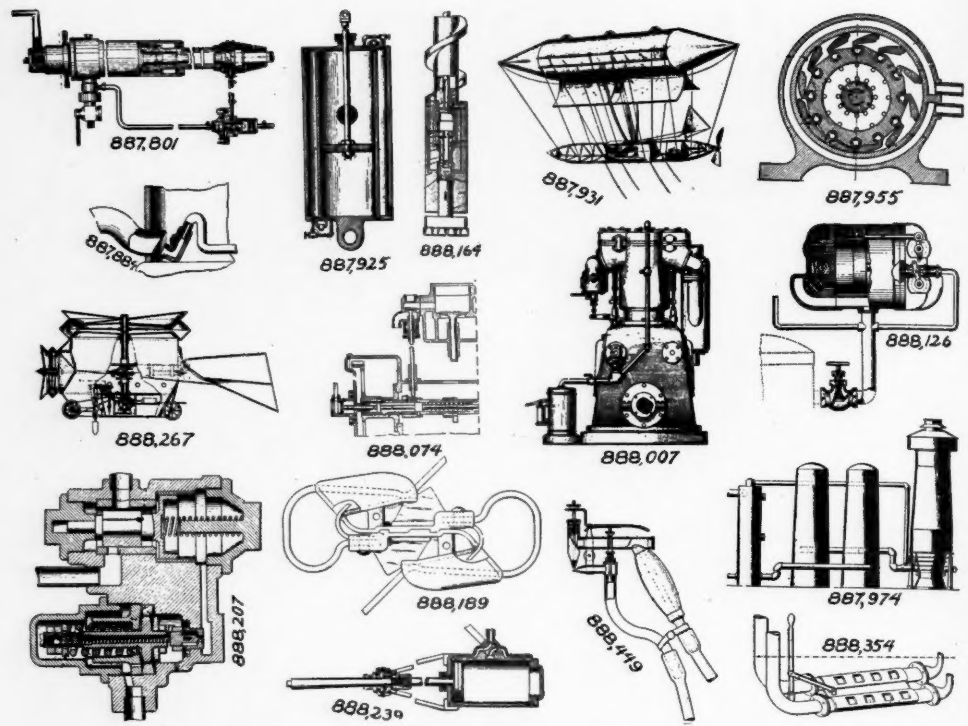
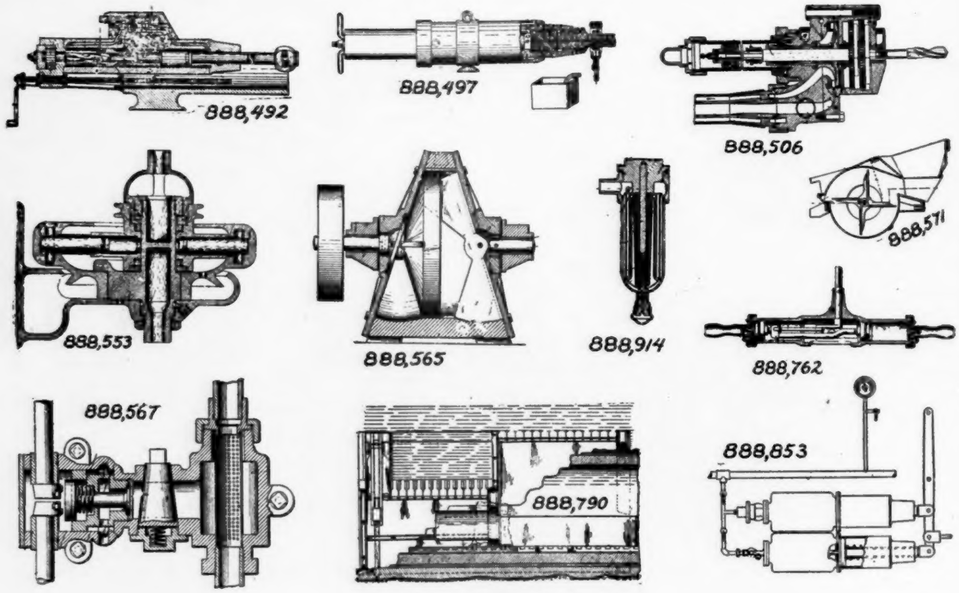


PNEUMATIC PATENTS, MAY 19.

shield and depressing the water level therein by an unbalanced pneumatic pressure.

888,853. AIR-BRAKE. CHARLES E. SHADE, Tacoma, Wash.

888,914. AIR-VALVE FOR RADIATORS. FRED W. LEUTHESSER, Chicago, Ill.



PNEUMATIC PATENTS, MAY 26.